(2)

STUDY REPORT
CAA-SR-88-19

E5/E6 TARGET GENERATION STUDY (TARGEN)

JULY 1988

PREPARED BY
FORCE SYSTEMS DIRECTORATE

US ARMY CONCEPTS ANALYSIS AGENCY
8120 WOODMONT AVENUE
BETHESDA, MARYLAND 20814-2797

CAA

DISCLAIMER

The findings of this report are not to be construed as an official Department of the Army position, policy, or decision unless so designated by other official documentation. Comments or suggestions should be addressed to:

Director
US Army Concepts Analysis Agency
ATTN: CSCA-FS
8120 Woodmont Avenue
Bethesda, MD 20814-2797

CAA-SR-88-19

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

Form Approved
OMB No 0704-0188
Exp. Date: Jun 30, 1986

1a. REPORT SECURITY CLASSIFICATION
UNCLASSIFIED

1b. RESTRICTIVE MARKINGS

2a. SECURITY CLASSIFICATION AUTHORITY

2b. DECLASSIFICATION/DOWNGRADING SCHEDULE

3. DISTRIBUTION/AVAILABILITY OF REPORT

4. PERFORMING ORGANIZATION REPORT NUMBER(S)
CAA-SR-88-19

5. MONITORING ORGANIZATION REPORT NUMBER (S)

6a. NAME OF PERFORMING ORGANIZATION
US Army Concepts Analysis Agency

6b. OFFICE SYMBOL (if applicable)
CSCA-FSP

7a. NAME OF MONITORING ORGANIZATION

6c. ADDRESS (City, State, and ZIP Code)
8120 Woodmont Avenue
Bethesda, MD 20814-2797

7b. ADDRESS (City, State, and ZIP Code)

8a. NAME OF FUNDING/SPONSORING ORGANIZATION
DCSPER

8b. OFFICE SYMBOL (if applicable)
DAPE-MBF

9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER

6c. ADDRESS (City, State, and ZIP Code)
Headquarters, Department of the Army
Washington, DC 20210-0300

10. SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT ACCESSION NO

11. TITLE (Include Security Classification)
E5/E6 Target Generation (TARGEN) Study (UNCLASSIFIED)

12. PERSONAL AUTHOR(S)
Dr. Elizabeth N. Abbe; CPT Eric M. Hughes; Ms. Kumud Mathur

13a. TYPE OF REPORT
Final

13b. TIME COVERED
FROM: Aug 87 TO Jul 88

14. DATE OF REPORT (Year, Month, Day)
1988 July

15. PAGE COUNT
202

16. SUPPLEMENTARY NOTATION

17. COSATI CODES

FIELD	GROUP	SUB-GROUP

18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
Statistical smoothing techniques; authorization patterns; enlisted promotions; authorized strength; target strength; fill; operating strength fill.

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

Alternate target generation processes were developed and evaluated for the purpose of leading to better maintainence of Army personnel operating strength relative to authorized strength within the E5/E6 enlisted promotion system. ("Targets" are adjusted projected authorizations used to determine future manpower requirements.) Evaluation of alternate target generation processes was based on simulation of the E5/E6 promotion system for 12 successive months (February 1987-January 1988) over all MOS in grades E5 and E6. Three target generation processes are identified which show some superiority to the current process. The key observation of the study is that operating strength for E5/E6 can be maintained close to authorized strength, even when statistical smoothing of fluctuations in the authorizations is essentially eliminated. Promotions to enlisted grades E5 and E6 are currently determined relative to complex computational derivations of the authorizations, not to the raw authorizations. Keywords: Enlisted personnel specialists;

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT
☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS

21. ABSTRACT SECURITY CLASSIFICATION
UNCLASSIFIED

22a. NAME OF RESPONSIBLE INDIVIDUAL
ELIZABETH N. ABBE

22b. TELEPHONE (Include Area Code)
301-295-0257

22c. OFFICE SYMBOL
CSCA-FSP

DD FORM 1473, 84 MAR — 83 Apr edition may be used until exhausted. All other editions are obsolete

SECURITY CLASSIFICATION OF THIS PAGE
UNCLASSIFIED

88 12 27 122

STUDY REPORT
CAA-SR-88-19

E5/E6 TARGET GENERATION STUDY (TARGEN)

JULY 1988

Accesion For	
NTIS CRA&I	✓
DTIC TAB	☐
Unannounced	☐
Justification	
By per ltr	
Distribution	
Availability Codes	
Dist	Avail and/or Special
A-1	

Prepared by

FORCE SYSTEMS DIRECTORATE

US Army Concepts Analysis Agency
8120 Woodmont Avenue
Bethesda, Maryland 20814-2797

DEPARTMENT OF THE ARMY
US ARMY CONCEPTS ANALYSIS AGENCY
8120 WOODMONT AVENUE
BETHESDA, MARYLAND 20814-2797

REPLY TO
ATTENTION OF

CSCA-FSP (5-5d) 08 NOV 1988

MEMORANDUM FOR: Deputy Chief of Staff for Personnel, ATTN: DAPE-MBF, Headquarters, Department of the Army, Washington, D.C. 20310-0300

SUBJECT: E5/E6 Target Generation (TARGEN) Study

1. The Deputy Chief of Staff for Personnel requested that the U.S. Army Concepts Analysis Agency (CAA) develop and evaluate alternate target generation processes for the E5/E6 promotion system. This request has been met. This report presents alternate target generation processes which are evaluated relative to the current process. Evaluation is based on the simulation of the E5/E6 promotion system for 12 consecutive months (February 1987 through January 1988) over all MOS in grades E5 and E6. This report also contains an executive summary which provides a methodology overview, key findings, and observations.

2. Your comments and critique of the study are included as Appendix J of the study report.

3. This Agency expresses appreciation to all agencies which have contributed to this study. Questions and/or inquiries should be directed to the Chief, Personnel Systems Analysis Division, Force Systems Directorate, U.S. Army Concepts Analysis Agency, 8120 Woodmont Avenue, Bethesda, MD 20814-2797, AUTOVON 295-5289.

E. B. Vandiver III

E. B. VANDIVER III
Director

CAA	E5/E6 TARGET GENERATION (TARGEN) STUDY	STUDY SUMMARY CAA-SR-88-19

THE REASON FOR PERFORMING THE STUDY was to develop and evaluate alternate target generation processes to better maintain Army personnel operating strength relative to authorized strength within the enlisted system for promoting into grades E5 and E6.

THE PRINCIPAL FINDINGS OF THE STUDY are: three processes have been identified which show superiority to the current target generation process. No one process was determined best for both grades E5 and E6 in all measurements of fill (the ratio of operating strength to authorized strength).

(1) The target generation process which uses authorizations as targets is superior to the current process by increasing percentages of balanced MOS from 52 percent to 58 percent, grade E5, and from 54 percent to 57 percent, grade E6. (Balanced MOS is the category of fill, defined by the Army Enlisted Personnel Management Plan, for which operating strength is within 95 to 105 percent of authorized strength. Categories of fill outside this range reflect strength imbalance.) In grade E6, using authorizations as targets also results in the best distribution of MOS over all categories of fill, fewer shortages (an average of 32 soldiers per month), and fewer overages (an average of 22 soldiers per month), relative to the current process. In grade E5, however, this target generation process increases shortages by 420 per month and overages by 81 per month.

(2) Another target generation process, which selectively smoothes authorizations that experience abrupt fluctuations, is also superior to the current target process in achieving high percentages of balanced MOS (58 percent, grade E5, and 57 percent, grade E6). This selective smoothing also reduces the average number of soldiers understrength per month by 594, grade E5, and by 521, grade E6. Increased overages occur, however, by an average of 464 per month, grade E5, and 219 per month, grade E6, relative to the current process.

(3) The best target generation process identified for grade E5 modifies the current process by smoothing the few authorizations identified as outliers in the final stage of the target computations. This process improves percentages of balanced MOS in grade E5 from 52 percent to 55 percent, maintains the best distribution of MOS over all categories of fill, reduces average numbers of shortages by 59 soldiers per month and overages by 97 soldiers per month, relative to the current process.

THE KEY OBSERVATION. Operating strength for E5/E6 can be maintained close to authorized strength, even when statistical smoothing of fluctuations in the authorizations is essentially eliminated. Promotions to enlisted grades E5 and E6 are currently determined relative to complex computational derivations of the authorization, not to the raw authorizations.

THE MAIN ASSUMPTION is: simulation of the E5/E6 promotion system based on the 12 most recent months of available data (February 1987-January 1988) will be sufficient for evaluation.

THE PRINCIPAL LIMITATION is: distinct complexities characteristic of the semicentralized promotion system, on which evaluation of alternate target generation processes is based, limits generalization of findings to grades other than E5 and E6.

THE SCOPE OF THE STUDY is limited to examination of alternate target generation processes as affecting the E5/E6 promotion system from February 1987 through January 1988, with evaluation based on fill (operating strength relative to authorized strength).

THE STUDY OBJECTIVES are:

(1) Evaluate the current target generation process based on the measurement of fill (operating strength relative to authorized strength) of enlisted grades E5 and E6 over all MOS and time.

(2) Develop and evaluate alternate methods for target generation based on the measurement of fill of enlisted grades E5 and E6 over all MOS and time.

THE BASIC APPROACH was to evaluate current and alternate target generation processes based on simulations of the E5/E6 promotion system for 12 consecutive months (February 1987 through January 1988) over all MOS in grades E5 and E6.

THE STUDY SPONSOR was the Military Personnel Management Directorate (DAPE-MP) of the Office of the Deputy Chief of Staff for Personnel (ODCSPER).

THE STUDY EFFORT was directed by Dr. Elizabeth N. Abbe, Force Systems Directorate.

COMMENTS AND QUESTIONS may be referred to the Director, US Army Concepts Analysis Agency, ATTN: CSCA-FS, 8120 Woodmont Avenue, Bethesda, MD 20814-2797.

Tear-out copies of this synopsis are at back cover.

CONTENTS

FIGURES

TABLES

CHAPTER 1

EXECUTIVE SUMMARY

1-1. BACKGROUND

a. Promotions into the enlisted grades E5 and E6 are determined every month from a semicentralized analytical system by individual military occupational specialty (MOS). The Office of the Deputy Chief of Staff for Personnel (ODCSPER) provides policy direction for the system and the United States Total Army Personnel Agency (TAPA) operates the system to determine the actual monthly promotions. Crucial input, in the form of projected adjusted authorizations for each MOS and grade, is provided by General Research Corporation (GRC) through the Military Occupational Specialty Level System (MOSLS) on FORECAST, the Headquarters, Department of the Army, Decision Support System.

b. Throughout this study, different personnel strengths are discussed. Authorizations or authorized strength can be thought of as the number of soldiers the Army has decided to fill in each MOS and grade. Authorizations are derived from the Personnel Authorizations Module (PAM) which is updated monthly. For planning purposes, authorizations are projected over the next 7 fiscal years. These projections are used for determining promotions as well as planning training requirements. These authorization projections tend to fluctuate over time as a result of equipment changes and activation and deactivation of units. Operating strength is the number of soldiers the Army has assigned to different units, not including trainees, transients, holdees, and students (TTHS).

c. The fundamental criterion for evaluating the effectiveness of the E5/E6 promotion system is based on the measurement of operating fill. Operating fill is the ratio of operating strength to authorized strength. Operating fill at or near 100 percent in each MOS over successive months is indicative of an effective system. The process of maintaining operating fill has two distinct components. The first component is the process which generates targets, which are adjustments made to the projected authorizations to better meet manpower requirements over time. Targets are adjusted projected authorizations. There are three major reasons for using targets in lieu of raw authorizations. The use of operating strength targets provides a capability to (1) correct known errors in the authorization data base, (2) account for undocumented personnel requirements, and (3) provide for manning ramps with the appropriate lead time or lag time when authorizations are increasing or decreasing. The second component is moving operating strengths to the targets or target strength. This can be done through reclassifications, accessions of prior service personnel, reenlistments, and promotions. This study focuses on promotions, since this is the primary method of adjusting the operating strength.

1-2. THE PROBLEM. A study to evaluate the effectiveness of the target generation process with respect to maintaining operating fill--over all MOS, in grades E5 and E6, and over time--has not previously been performed. Nor has the potential of developing an optimal target generation process been fully explored. This study focuses on the relationships between authorizations, targets, and the resulting operating strengths to satisfy the Army's goal of investigating how the Army can improve the process of moving operating strength to authorized strength.

1-3. STUDY OBJECTIVES

a. Evaluate the effectiveness of the current target generation process based on the measurement of fill (operating strength relative to authorized strength) of enlisted grades E5 and E6 over all MOS and over time.

b. Develop and evaluate alternate methods of target generation based on the measurement of fill (operating strength relative to authorized strength) of enlisted grades E5 and E6 over all MOS and time.

1-4. THE STUDY SCOPE. The objectives are evaluated on the basis of the study scope specified as follows.

a. This study is limited to examination of analytical modifications pertaining to the target generation process of the current E5/E6 promotion system.

b. Examination of the current and modified E5/E6 promotion system is based on 12 consecutive simulations of the system for the 12 most recent months of historical authorizations and targets (February 1987-January 1988) for all MOS in grades E5 and E6 common to the 12 months of analysis (265 MOS, grade E5, and 242 MOS, grade E6).

c. Evaluations of the current system and modifications to the current system are based on fill (operating strength relative to authorized strength). Different variations in the measurements of fill which are applied to this study are:

- Numbers of MOS in different categories of fill.
- Strength in different categories of fill.
- Magnitude of understrength (the number of soldiers who are needed to fill MOS, over all MOS for which operating strength is less than target strength).
- Magnitude of overstrength (the number of soldiers who exceed target strength, over all MOS for which operating strength is greater than target strength).

d. Categories of fill (as defined by the Army Enlisted Personnel Management Plan (EPMP), FY 1987 - FY 1991) which will be applied to this study are:

- Number of critically imbalanced MOS, underfill: $\text{fill} <= .80$
- Number of moderately imbalanced MOS, underfill: $.80 < \text{fill} <= .95$

- Number of balanced MOS:
  .95 < fill < = 1.05

- Number of moderately imbalanced MOS, overfill:
  1.05 < fill < = 1.20

- Number of critically imbalanced MOS, overfill:
  fill > 1.20

1-5. LIMITATIONS

a. Limited availability of historical authorizations and targets makes reproduction of the E5/E6 promotion system possible for only 12 months of consecutive analysis.

b. Evaluation of alternate target generation processes is based on simulation of the E5/E6 promotion system. In that unique complexities are characteristic of this system, generalization of findings to other manning systems may not be possible.

1-6. TIMEFRAME. February 1987 - January 1988.

1-7. KEY ASSUMPTION. Simulation of the E5/E6 promotion system based on 12 months of the most recent available data within FY 1987-1988 will be sufficient for evaluative purposes.

1-8. THE APPROACH/METHODOLOGY. Study methodology consists of (a) development of alternate target generation processes, (b) simulation of the E5/E6 promotion system as affected by alternate target generation processes, and (c) evaluating performance of the E5/E6 promotion system based on measures of operating fill.

a. Alternate Target Generation Processes. In order that operating strength can more realistically follow abrupt fluctuations which occur in the projected authorizations, it is customary to "smooth" the authorizations using statistical smoothing techniques. Thus, the original focus of the study was on these abrupt fluctuations and on the most effective application of statistical smoothing techniques to smooth the fluctuations. The smoothing of authorizations occurs at the third stage of a six-stage computational process used to generate targets. The six-stage process is shown as path 1 of Figure 1-1 and is described below. Emerging results indicated, however, that evaluation of variations of the six-stage computational process, rather than different statistical smoothing techniques, would lead to results having more impact on fill. Consequently, target generation processes were conceptualized as five different paths, as illustrated in Figure 1-1.

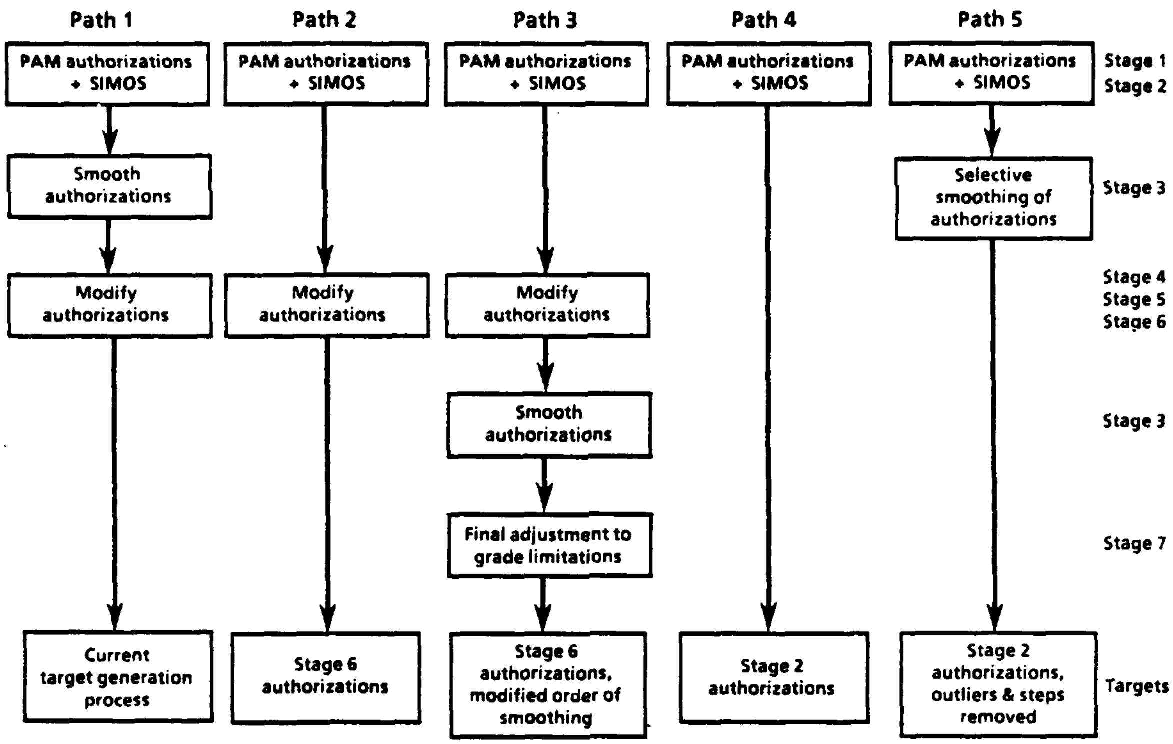


Figure 1-1. Target Generation Process

(1) Path 1 (current target generation process). Path 1 of Figure 1-1 represents the current target generation process which consists of six computational stages:

(a) The source of the stage 1 authorizations is the Personnel Authorizations Module of the FORECAST/MOSLS system.

(b) Authorizations can be inflated in stage 2 to account for undocumented personnel requirements.

(c) Smoothing authorizations occurs in stage 3. Examples of statistical smoothing techniques included in this study are (1) weighted moving average, (2) Tukey-Riffenberg method, (3) exponential smoothing, (4) removal of outliers method, and (5) ramp method. A description of the statistical smoothing techniques can be found in Chapter 3.

(d) Authorizations are additionally adjusted to meet Armywide strength projections, to incorporate trainees, holdees, and students, and, finally, to meet constraints by grade (stages 4, 5, and 6).

(2) Path 2 (stage 6 authorizations). Path 2 is a reproduction of the current target generation process, but with the smoothing eliminated.

(3) **Path 3 (stage 6 authorizations, modified order of smoothing).** In path 3, the smoothing of authorizations is moved to occur subsequent to stages 4, 5, and 6.

(4) **Path 4 (stage 2 authorizations).** In path 4, the stage 2 authorization is directly used as the target.

(5) **Path 5 (stage 2 authorizations with outliers and steps removed).** Path 5 refers to the selective smoothing of stage 2 authorizations which fluctuate as outliers or which take the shape of steps.

b. Simulation of the E5/E6 Promotion System. Evaluation of alternate target generation processes based on simulation of the E5/E6 promotion system is illustrated in Figure 1-2. Targets are used to determine numbers needed for promotion. When operating strength is less than target strength, vacancies occur, and the Army promotes to fill vacancies. The accumulated effect on operating strength which occurs as the result of promotions derived from different targets--for all MOS in grades E5 and E6 and over 12 successive months--is the product of the simulation.

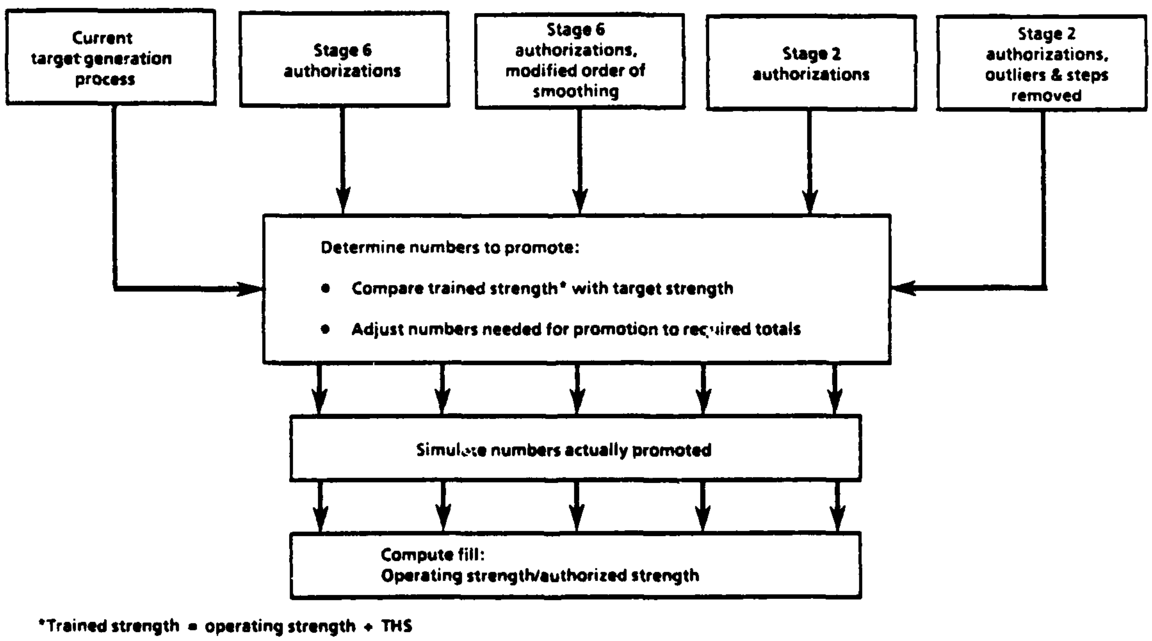


Figure 1-2. Comparing Target Generation Processes

c. **Complexities.** In addition to the effect of the target, a number of complexities exist within the E5/E6 promotion system which affect operating fill. The five most significant complexities are described below.

(1) **Projections.** Promotions are determined for 1 month in the future. About 2 months are required to develop records of actual operating strength. Consequently, the time span between the most recent available records and the month for which promotions are needed covers 3 months; that is, promotions are based on projections 3 months ahead.

(2) **Constraints on Numbers Needed.** A ceiling on total numbers of promotions into grades E5 and E6 is provided every month. Consequently, numbers needed, as determined by the difference between projected operating strength and the target, are constrained to meet the required sum. (The constrained numbers needed are referred to as "promotion determinations.")

(3) **Differences Between Promotion Determinations and Actual Numbers Promoted.** The promotion determination is used to derive a "cutoff score" for every MOS in grades E5 and E6. Soldiers eligible for promotion into grades E5 and E6 who have cumulations of promotion points which are equal to or exceed the cutoff score are automatically promoted. Ideally, actual numbers promoted should equal the promotion determinations, but differences do occur.

(4) **Insufficient Eligible Soldiers and Overfill.** Too few soldiers eligible for promotion or prior existence of overfill may obscure the effect of any given target.

(5) **Changing Authorizations Documents.** Effectiveness of the E5/E6 promotion system is based on reports of operating strength relative to authorized strength produced monthly by ODCSPER. Changes in authorizations documents, however, occur every month. Consequently, the authorization which drives the generation of the target and the determination of numbers needed for promotion may not be the authorization upon which the report of operating fill is based.

d. **Simulation of These Complexities.** To partially reduce complexities which confound the relationship between the target and operating fill, complexities (1) and (5) above were not included in the simulation of the E5/E6 promotion system. Complexities (2), (3), and (4) above, which represent distinct characteristics of the E5/E6 promotion system, however, were incorporated into the simulation. Study findings may be expected to be valid for the E5/E6 promotion system, but may not be generalized to other manning systems.

e. **Evaluation Based on Fill.** Evaluation of target generation processes is based on multiple measures of fill. Ideally, an improved process will have (1) increased numbers/percentages/strength of MOS categorized as balanced, (2) decreased numbers/percentages/strength of MOS in categories of underfill or overfill, and (3) decreased numbers of shortages and overages. Realistically, a process which improves balance may shift remaining imbalance from underfill to overfill (or vice versa). In evaluating the effects of the different processes, an effort is made to describe how the processes change the distribution of results with respect to balance/imbalance and shortages/overages. A process which improves balance but still accentuates underfill may be acceptable in one manpower environment, whereas a process which improves balance but accentuates overfill may be acceptable in another.

1-9. ESSENTIAL ELEMENTS OF ANALYSIS (EEA). The structure of this study focused on the questions asked in the essential elements of analysis (EEA) listed below. In this paragraph and in the following chapters, EEA 5 (as originally stated in the study directive in Appendix B) is presented after EEA 6 to provide an overall summary of results. Throughout this paragraph references are made to the alternate target generation processes described earlier in Figure 1-1. The current target generation process shown in path 1 has two versions of current targets, "historical" and "current." "Historical" targets are recreated by reading from actual records used from February 1987 through January 1988. In the first 7 of these 12 months, a double exponential smoothing technique was originally used to produce these targets; in the second 5 months (September through January), a weighted moving average technique was used. "Current" targets refer to a recomputation to produce targets for all 12 months using the current weighted moving average technique.

a. **EEA 1: How do current targets compare with authorizations, based on measures of fill?**

RESPONSE

(1) Figure 1-3 shows a comparison of current targets with authorizations for grade E5. As shown, stage 2 authorizations and stage 6 authorizations are both superior to current and historical targets in terms of percentages of balanced MOS. The greater superiority (by 6 percent balanced MOS), however, occurs for the stage 2 authorization, relative to the current method.

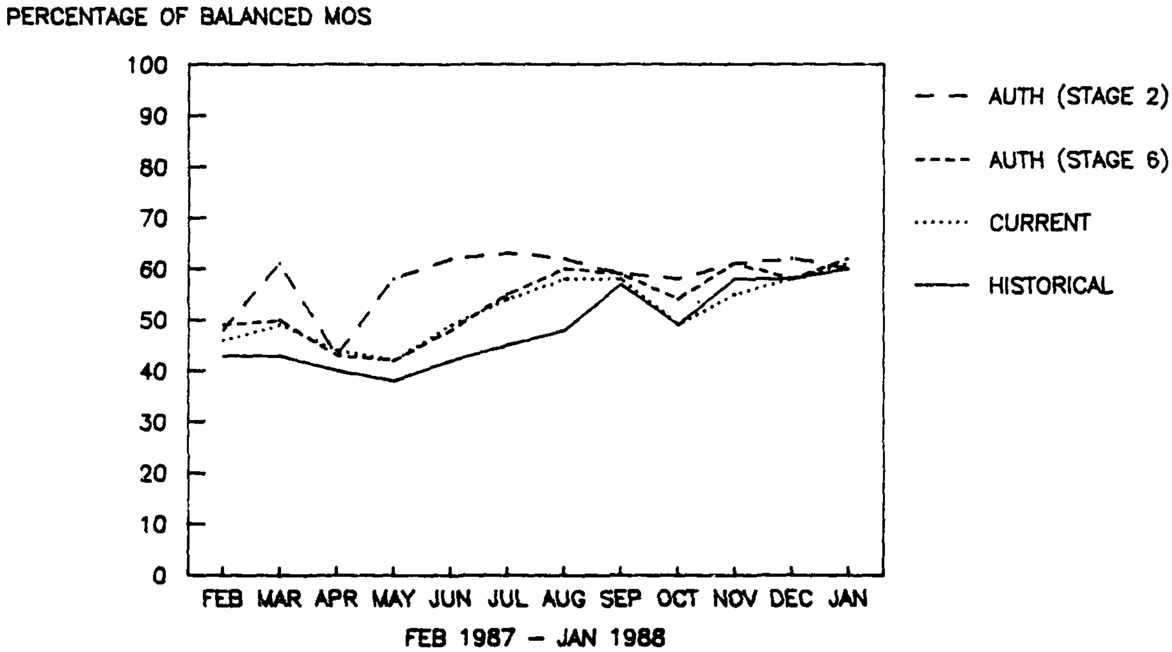


Figure 1-3. Comparing Current Targets with Authorizations, Grade E5

(2) Current targets are shown to be distinctly better than historical targets. Thus, the implementation of the current method was demonstrated to be a good decision.

b. EEA 2: What are the characteristics of those authorization patterns that produce large differences between operating strength, targets, and authorizations?

RESPONSE. While looking at projected authorizations, different characteristics of patterns were identified and categorized by outliers, sharp increases/decreases (steps), seasonality, ascending/descending authorizations, turbulence, changes in new authorization documents, as well as the authorization size of the MOS. Only some of these authorization patterns examined showed differences between operating strength and targets evaluated based on the percentage of fill. The authorization size showed that the smaller the size of the MOS, the smaller the percentage of balanced MOS occurred. Highly turbulent MOS within an authorization document and updating the new authorization documents also showed a low percentage of balanced MOS.

c. **EEA 3: What is the most effective method of generating targets for each pattern?**

RESPONSE. In determining the most effective method of generating targets, different statistical smoothing techniques were developed. These techniques included a weighted moving average, an exponential smoothing technique, the Tukey-Riffenberg technique, the removal of outliers techniques, the ramp technique, and the Tukey and outlier techniques combined. When these techniques were applied to the different patterns, no one technique was found superior relative to the current technique. Some patterns, however, showed a large increase in percentage of balanced MOS between the "historical" and the "current" technique which demonstrated that implementing the current technique was a good decision.

d. **EEA 4: If smoothing of the authorizations is appropriate, when in the target generation process should it be performed?**

RESPONSE

(1) Table 1-1 compares different statistical smoothing techniques smoothed at stage 2 and at stage 6 for grade E5. As shown, smoothing of authorizations should be applied to stage 6 authorizations rather than to stage 2 authorizations, when smoothing is by straight line removal of outliers ("Auth(stage 6)-outliers(SL)") or by the Tukey-Riffenberg statistical technique ("Auth(stage 6), T").

Table 1-1. Smoothing Order Comparisons, Percentage of MOS in Categories of Fill (8702-8801), Grade E5

Target process	Category of fill					
	Critically under	Moderately under	Balanced	Moderately over	Critically over	Total
Auth (stage 2), C	4	20	52	14	11	100
Auth (stage 6), C	4	20	52	14	11	100
Auth (stage 2), T	4	19	53	14	11	100
Auth (stage 6), T	4	19	54	13	11	100
Auth (stage 2) – outliers (SL)	4	19	53	14	11	100
Auth (stage 6) – outliers (SL)	4	17	55	13	10	100
Auth (stage 2) – outliers (MA)	4	18	53	14	11	100
Auth (stage 6) – outliers (MA)	4	19	52	14	11	100
Auth (stage 6)	4	19	53	13	11	100

C = Current smoothing technique; T = Tukey statistical smoother; SL = straight line method of removal of outliers; MA = moving average method of removal of outliers.

(2) The greatest improvement with respect to distribution of MOS in categories of fill occurs when straight line smoothing of outliers is applied to stage 6, rather than to stage 2 authorizations (percentage of balanced MOS increased by 2 percent and percentages of MOS over the four imbalance categories decreased by a total of 4 percent.

e. **EEA 6: What are the effects of incorporating consideration of the availability of the soldiers eligible for promotion, the existence of overfill, the protection of space imbalanced MOS (SIMOS), and other constraints on fill, for each MOS at grades E5 and E6, over time?**

RESPONSE. Considering availability of soldiers eligible for promotion, the existence of overfill, and the protection of SIMOS did not lead to improved target methodology. Difficulties were associated with the protection process, in that protecting large MOS in some months of analysis prevented the necessary reduction of numbers needed for promotion to required promotion ceilings.

f. **EEA 5: How do alternate target generation processes compare with the current process?**

RESPONSE

(1) The current target generation process, in which authorizations are smoothed with a five-point weighted moving average ("current" targets), is distinctly better than an earlier version of the same process, in which authorizations were smoothed using an exponential smoothing technique ("historical" targets). This current target generation process is slightly improved further by different statistical smoothing techniques.

(2) Of all target generation processes evaluated, the process which exists simply as stage 2 authorizations results in the greatest observed increase in percentages of balanced MOS relative to the current process (an increase of 6 percent, grade E5, and an increase of 3 percent, grade E6). Consistent superiority of the stage 2 authorizations relative to the current process, however, does not occur. The stage 2 authorizations are associated with an accentuated underfill in grade E5. A more complex version of the stage 2 authorizations, selective smoothing of stage 2 authorizations identified as outliers and step functions, maintained the same high percentage of balanced MOS observed for the simpler version. Of all target generation processes compared, the complex version of stage 2 authorizations resulted in the fewest shortages; however, it also produced more overages per month than did the current process.

(3) Small superiority to the current process in grade E5 did exist for stage 6 authorizations, the target generation process which is identical to the current process except that smoothing of authorizations is eliminated. A more complex version of the stage 6 authorizations was the "straight line smoothing of stage 6 authorizations identified as outliers." This more complex version improved the small superiority observed for the simpler version. Compared with the current process, percentages of balanced MOS were increased and MOS in categories of underfill and overfill were decreased in both grades E5 and E6.

1-10. OVERALL FINDINGS. Based on the comparison of distinct target generation processes drawn from alternate processes examined in Chapters 5 through 10, three processes have been identified which show superiority to the current process with respect to the variations in the measurements of fill. No single technique was found superior for both grades E5 and E6.

a. Stage 2 Authorizations. In grade E5, stage 2 authorizations are superior with respect to percentages of balanced MOS. They are inferior, however, with respect to percentages of MOS which are critically imbalanced, underfill, and total numbers of shortages and overages. In grade E6, stage 2 authorizations are superior with respect to both highest percentages of balanced MOS and fewest shortages and overages.

b. Stage 2 Authorizations, Selectively Smoothed. Of all processes evaluated, targets which also exist as stage 2 authorizations, but selectively smoothed for steps and outliers, maintain superiority of highest percentages of balanced MOS. In grade E5, this selective smoothing of stage 2 authorizations also results in the greatest reduction of underfill, but it accentuates overfill.

c. Stage 6 Authorizations Identified as Outliers. In grade E5, the most effective target generation process is generated by smoothing stage 6 authorizations identified as outliers. Although the highest percentages of balanced MOS are not associated with such targets, they do produce the best distribution of percentages of MOS over categories of underfill and overfill and the fewest shortages and overages observed in grade E5.

1-11. INSIGHTS

a. The Simulation

(1) TARGEN has been a study based on simulation of the total E5/E6 promotion system. As many quantifiable complexities as were known were incorporated into the simulation.

(a) The disadvantage of such a study approach is that it is difficult to track, through the many complexities of the system, the effect a given target has on operating strength.

(b) The advantage of simulating the total system, with all of its complexities, is that the magnitude of the effect which alternate target generation processes have on the total system can be precisely established.

(2) The simulation of the E5/E6 promotion system was useful in establishing relative impact on fill of the different components of the system. In that the current analytical process of reducing numbers needed for promotion to required promotion ceilings does not substantially reduce balanced fill, it is an effective process. It was also observed that discrepancies between the promotion determination and actual numbers promoted are associated with substantial reduction in balanced fill.

b. Target Generation Processes

(1) Time was lost exploring the original concept motivating initiation of this study: there are distinct patterns of fluctuations in authorizations and different statistical smoothing techniques should be effective for different patterns. Practical methods of improving balanced fill could not be developed from this concept.

(2) Subsequently, the concept of a target generation process was generalized to consist of variations of the computational stages used in the current target generation process. Certainly, even more general variations of the target generation process could be developed and systematically evaluated.

(3) Explaining the effect on fill produced by computational stages 4, 5, and 6 of the current target generation process is beyond the scope of this study. Authorizations are first moved up (inflated to total Army strength projections) and then back down to meet limitations by grade. In the middle of this contradictory computational process, projections of trainees, holdees, and students (THS) are incorporated. Little is known of the accuracy of these projections. What was observed about this current target generation process, however, is that it does not lead to accentuated underfill or overfill. Stage 6 authorizations, smoothed for outliers, were associated with good distributions of MOS over all categories of fill; extremes in shortages and overages were not reported.

(4) Stages 4 through 6 of the current target generation process clearly wash out the effect of the statistical smoothing of the stage 2 authorizations. That statistical smoothing can be very powerful, however, was demonstrated by the effect it had on the stage 2 authorizations, when subsequent computations on the stage 2 authorizations were eliminated. Statistical smoothing of steps and outliers in the stage 2 authorizations substantially reduced underfill, maintained the high percentages of balanced MOS associated with the stage 2 authorizations, but shifted imbalanced MOS in the direction of overfill.

c. Measures of Fill

(1) Results were evaluated on the basis of four different variations of the measure, fill: numbers, percentages, and strength of MOS in categories of fill and average understrength and overstrength per month. Rather than computing total strength of MOS in each category, it would have perhaps been more informative to have computed total number of soldiers either understrength or overstrength for each of the categories.

(2) Measurement dependent on category boundaries, which can be arbitrarily set, are always potentially misleading. Where so many changes in operating strength occur as a result of uncontrollable complexities which occur throughout the total E5/E6 promotion system, category boundaries as currently used appear to be overly refined.

(3) The one measure included in the study which was independent of category boundaries was total number of soldiers for which operating strength was less than authorized strength (shortages) and total number of soldiers for which operating strength was greater than authorized strength (overages). This measure was used throughout the study to supplement findings based on category boundaries.

1-12. KEY OBSERVATIONS

a. Operating strength in grades E5 and E6 can be maintained close to the authorized strength. The importance of fluctuations in the authorizations has been overrated. Promotions to grades E5 and E6 are currently made relative to complex computational derivations of the authorization, not the raw authorizations.

b. Additional work is needed to understand why the stage 2 authorizations can lead to extremes in number of shortages or number of overages, even though distinctly superior results were obtained for the stage 2 authorizations with respect to percentages of balanced MOS. Additional experimentation using the simulation of the E5/E6 promotion system should be profitable.

c. A basic assumption of this study is that 12 months of analysis is sufficient for establishing findings. More than 12 months of analysis would have been desirable, if historical authorizations and targets had been available. Major structural changes occur to authorizations documents every 6 months, and 12 months of analysis is insufficient to adequately evaluate the effects of such changes. In addition, turbulence in all measures of the E5/E6 promotion system was observed for the first 7 months of the timeframe of analysis; the system was more stable during the last 5 months. More analysis on how such turbulence relates to the findings would be desirable.

CHAPTER 2

BACKGROUND

2-1. INTRODUCTION. An attempt is made to maintain Army personnel operating strength at authorized strength by month, by grade, and by military occupational specialty (MOS). Changes occur in authorized strength over time, as well as in operating strength. In order that operating strength can more realistically follow abrupt fluctuations which occur in the authorizations, it is customary to "smooth" the authorizations using statistical smoothing techniques. In addition, authorizations may be inflated to account for undocumented personnel requirements (Space Imbalanced MOS (SIMOS), Directed Military Overstrength (DMO), and minimum authorized level of fill (MALOF) of selected units). Authorizations which exist as monthly projections of up to 7 fiscal years are additionally adjusted to meet Armywide strength projections to incorporate trainees, holdees, and students (the THS account), and finally, to meet constraints by grade. Adjusted, projected authorizations are referred to as targets.

2-2. THE STUDY PROBLEM. A study to evaluate the effectiveness of the target generation process with respect to maintaining operating fill--over all MOS, in grades E5 and E6, and over time--has not previously been performed. Nor has the potential of developing an optimal target generation process been fully explored. This study focuses on the relationships between authorizations, targets, and the resulting operating strengths to satisfy the Army's goal of investigating how the Army can improve the process of moving operating strength to authorized strength.

a. The process of maintaining operating fill (operating strength divided by personnel authorized strength) has two distinct components: (1) generating targets from projected authorizations, and (2) moving operating strength to the targets. Operating strength less than target strength creates a "vacancy." In the Army enlisted system, vacancies can be filled through reclassification, conversions of MOS, and through prior service accessions. Primarily, however, vacancies are filled through promotions.

b. Moving operating strength to the targets, as affected by methodology within the Army's promotion system for enlisted personnel in grades E5 and E6 was examined in the E5/E6 Enlisted Promotion Model (EPM, CAA-SR-87-6) Study. Operating fill, using targets which historically determined performance of the promotion system from April 1985 through March 1986, formed the basis for evaluation. EPM was thus an examination of the link between operating strength and the targets.

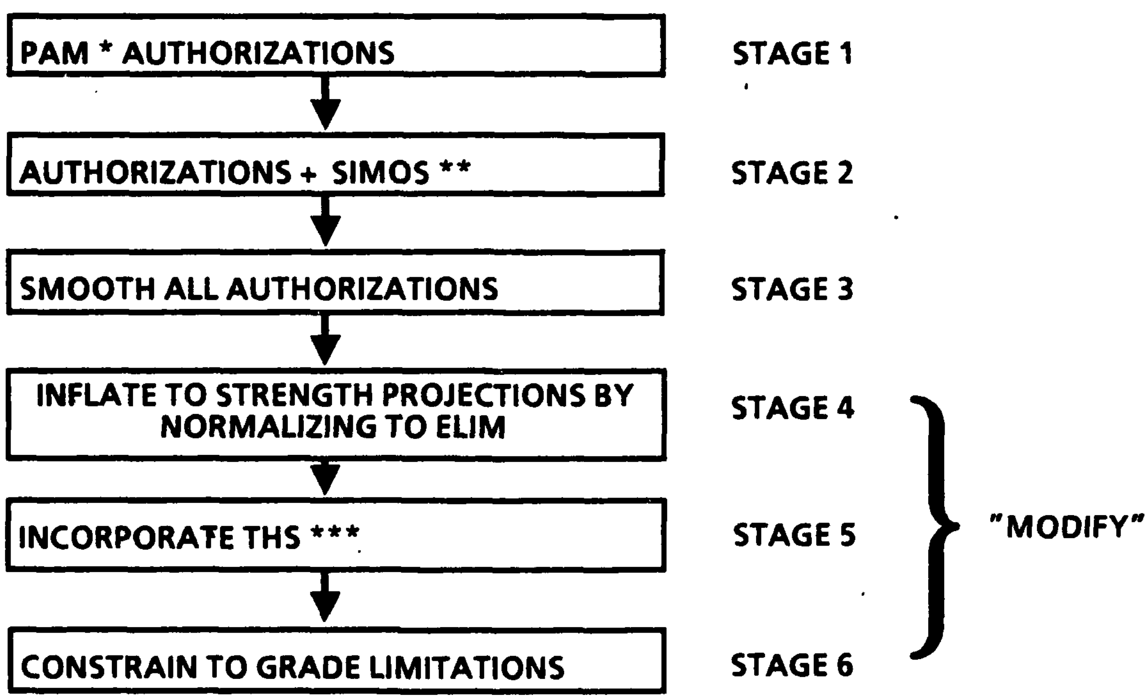
c. Under sponsorship of the Military Personnel Management Directorate (DAPE-MPD) of the Office of the Deputy Chief of Staff for Personnel (ODCSPER), the E5/E6 Target Generation Study (TARGEN) was initiated (January 1988). Within the E5/E6 promotion system, this study would focus on generating targets from authorizations, but with the objective of better moving operating strength to the authorizations. Establishing the relationships between authorizations, targets, and the resulting operating strengths would be expected to satisfy the Army's goal of fully investigating how the Army can improve the process of moving operating strength to authorized strength.

2-3. THE STUDY PURPOSE. The purpose of the study is to develop alternative methods of target generation for E5/E6 promotions, to compare these methods with the current method, and to identify the most effective method based on the measurement of fill (operating strength relative to authorized strength), over all MOS for enlisted grades E5 and E6.

2-4. BACKGROUND. TARGEN examines the target generation process as it affects the E5/E6 promotion system.

a. The Current Target Generation Process. Targets which are generated from personnel authorizations, are presented in Figure 2-1 as six computational stages. These computational stages exist as projections for each MOS and grade for every month through the end of the 7th fiscal year. An example for a single MOS and grade, for the target month January 1988, is plotted in Figure 2-2. For a clearer presentation of the six computational stages, this graph only plots the first 25 months of authorization projections.

SIX COMPUTATIONAL STAGES



*PAM: PERSONNEL AUTHORIZATIONS MODULE

**INFLATE BY SIMOS (SPACE IMBALANCED MOS) AND OTHER POLICY REQUIREMENTS

***THS: TRAINEES, HOLDEES, AND STUDENTS

Figure 2-1. The Current Target Generation Process is Six Computational Stages

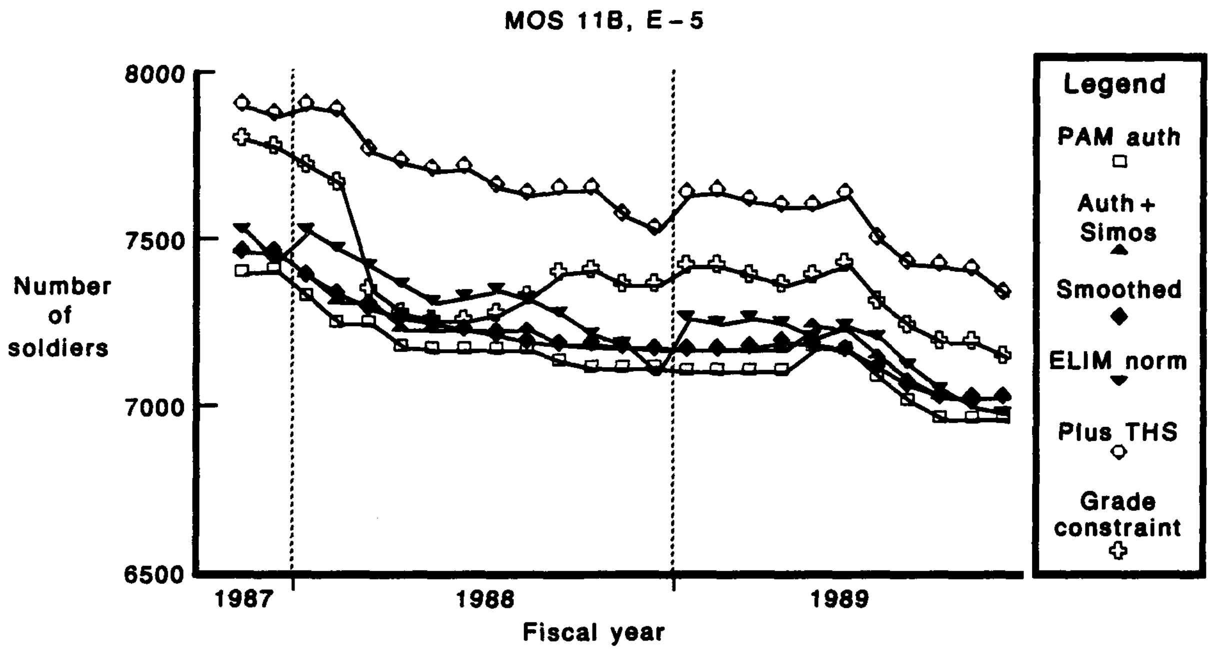


Figure 2-2. Changing Patterns of Authorization Stages

(1) **PAM Authorizations.** The stage 1 authorizations are formatted from authorizations documents each month. Such a set of authorizations is referred to as an "authorizations pattern." Major structural changes occur to authorizations (maintained on the Primary Authorizations Document Module (PMAD)) every 6 months, but monthly updates occur as Updated Authorizations Documents (UAD).

(2) **Authorizations plus SIMOS.** Authorizations in stage 2 correct for known errors in the authorization data base, account for undocumented personnel requirements (space imbalanced MOS (SIMOS)), directed military overstrength (DMO), and minimum authorized level of fill (MALOF) of selected units and provide for manning ramps with the appropriate lead time or lag time when authorizations are increasing or decreasing.

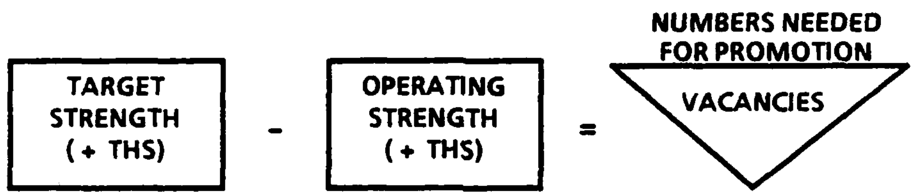
(3) **Smoothed Authorizations.** The Enlisted Loss Inventory Model (ELIM) is part of the Active Army Enlisted Personnel System. It is used in the target generation process to inflate smoothed authorizations to the total Army strength projections.

(4) **ELIM Normalization.** Inflation of smoothed authorizations to total Army strength projections occurs in stage 4.

(5) **Incorporate THS.** Trainees, holdees, and students (THS account) are added in stage 5.

(6) **Grade Constraint.** In the final stage of computations, authorizations are constrained to sum to overall grade limitations.

b. **The Current E5/E6 Promotion System.** Targets are used to determine numbers needed for promotion. At the heart of the E5/E6 promotion system is an equation which relates target strength to operating strength (Figure 2-3). Vacancies occur when operating strength is less than target strength, and the Army promotes to fill vacancies. A number of complexities exist within the E5/E6 promotion system which affect actual numbers promoted.



- **BY MOS**
- **BY GRADE**
- **FOR EVERY MONTH**

FINAL E5/E6 PROMOTION DETERMINATIONS:

NUMBERS NEEDED FOR PROMOTION CONSTRAINED TO THE PROMOTION CEILING FOR GRADE E5 AND FOR GRADE E6

Figure 2-3. The Target as Used in Determining E5/E6 Promotions

(1) **Projections.** Numbers needed for promotion are projected 1 month ahead. Most recent records of operating strength (the Enlisted Master File) are, however, 2 months old. Consequently, projections of operating strength must span a 3-month period (Figure 2-4). The 7 fiscal years of monthly target projections are generated from the same most recent Enlisted Master File as well as from authorizations documents. It is the third projection point of the target projections which is used to determine numbers needed for promotions. Projected operating strength is plotted adjacent to actual operating strength (all MOS, February 1987 - January 1988) for grades E5 and E6 in Figure 2-5.

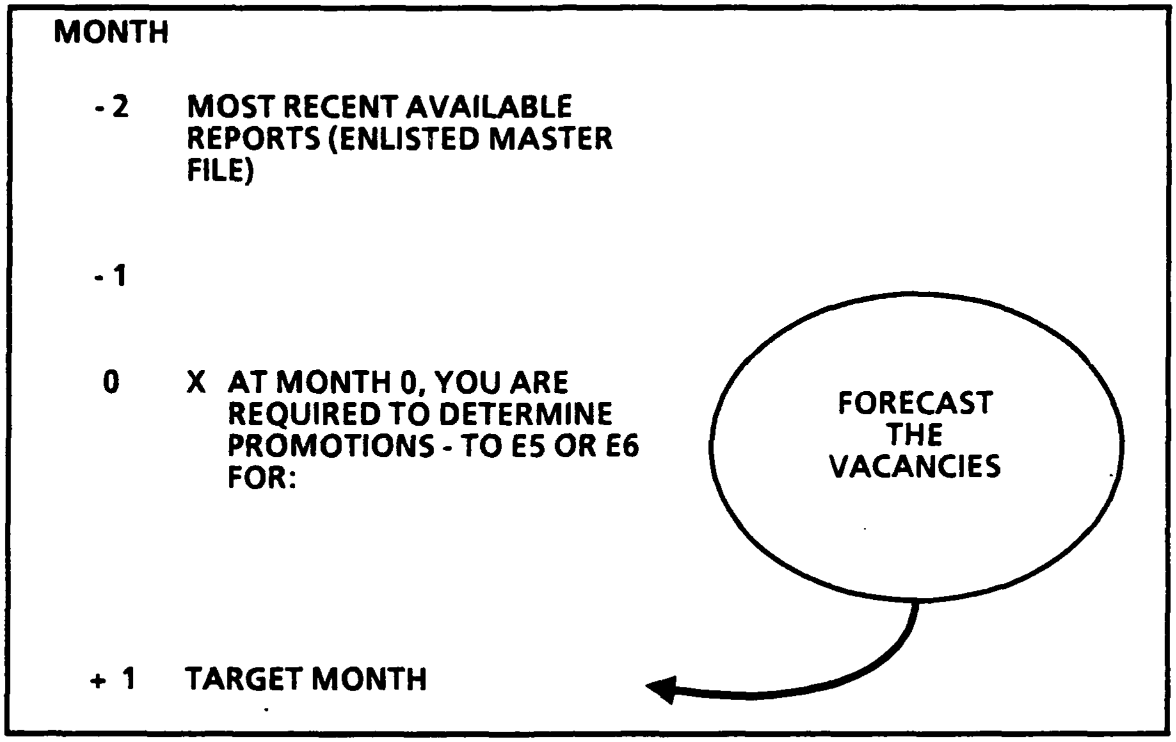


Figure 2-4. Timeframe of the Promotion Determination

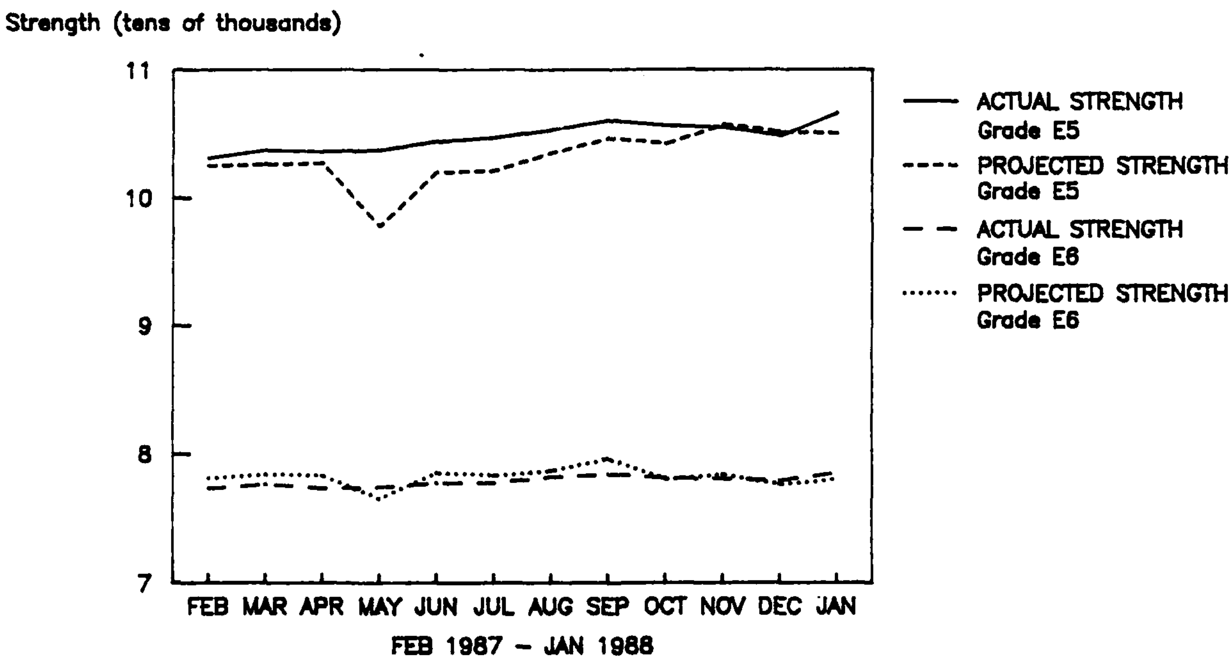


Figure 2-5. Comparison of Projected Operating Strength With Actual Operating Strength

(2) **Constraints on Numbers Needed.** Total numbers needed for promotion over all MOS in grade E5 or in grade E6 must be constrained to meet a prespecified ceiling on the total number of promotions. Constrained numbers needed for promotion which meet this ceiling are referred to as "promotion determinations." To illustrate magnitude of the constraint, numbers needed for promotion and promotion determinations (summed over all MOS by grade and month, February 1987 - January 1988) are plotted in Figure 2-6 (grade E5) and Figure 2-7 (grade E6).

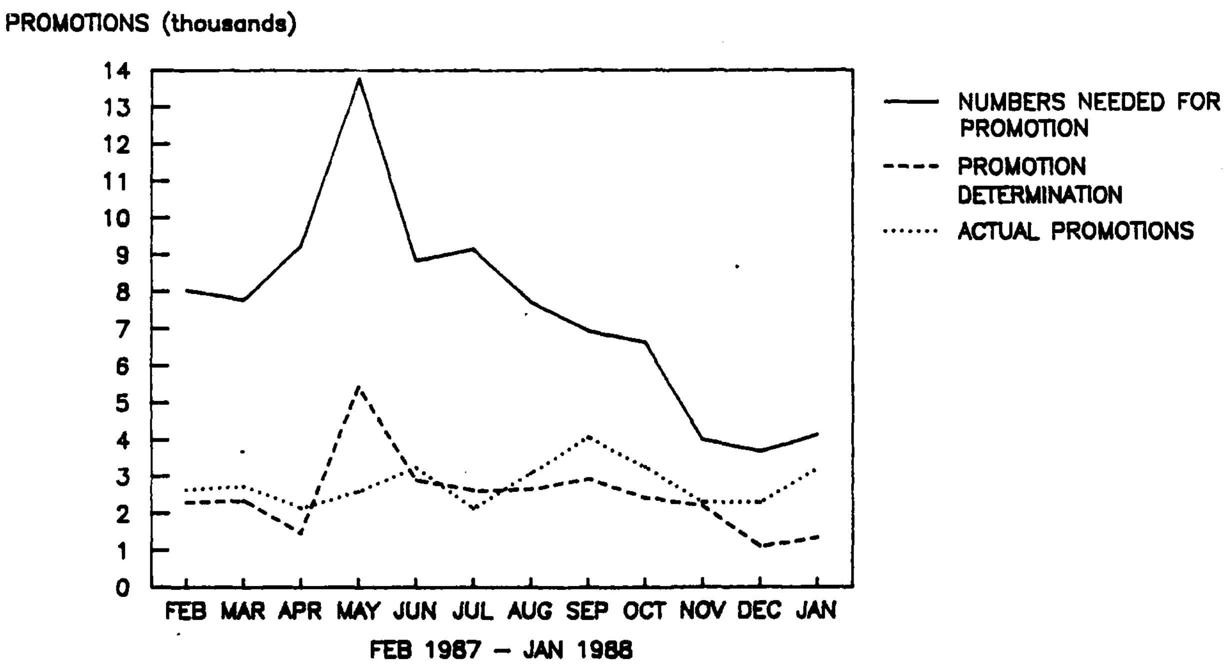


Figure 2-6. E5 Constraints on Numbers Needed for Promotion

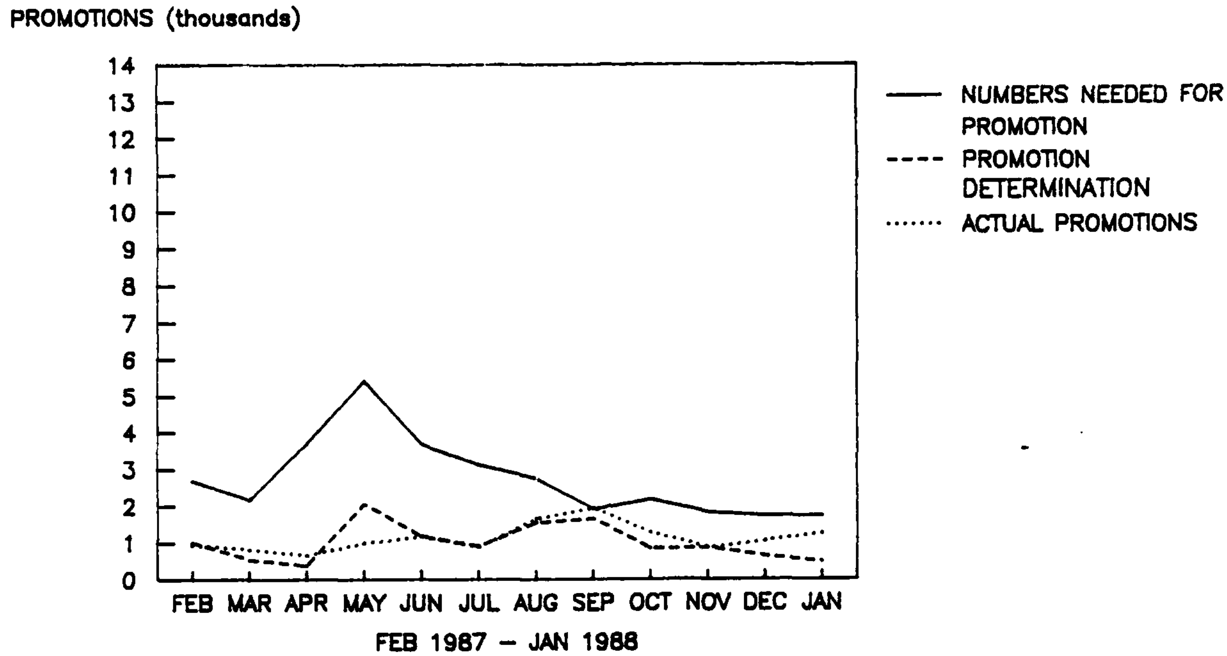


Figure 2-7. E6 Constraints on Numbers Needed for Promotion

(3) Differences Between Promotion Determinations and Actual Numbers Promoted. Unique to the E5/E6 promotion system is the cutoff score. Every month, a cutoff score, derived from central records, is announced for each MOS in grades E5 and E6. These records relate promotion determinations to actual numbers of soldiers who hold cumulations of "promotion points." Soldiers eligible for promotion into grades E5 and E6 who hold promotion points at least as great as the cutoff score are automatically promoted. Ideally, numbers actually promoted should equal the promotion determination. Magnitudes of the differences which exist between numbers actually promoted and the promotion determinations are illustrated in Figures 2-6 and 2-7. Contributing to these differences is a time lag of about 1-1/2 months required to develop the central records from Armywide reports of promotion scores awarded to promotion eligible soldiers after appearances before unit selection boards. During this time lag, eligible soldiers may leave the Army (thus, too few soldiers will be promoted) or they may improve their promotion point standing by having requested reevaluation from the selection board (resulting in too many promotions).

(4) Different Computations of Fill. DCSPER monthly reports, which evaluate operational effectiveness of the E5/E6 promotion system, compute actual operating strength relative to authorized strength derived from the most recent authorizations document. Numbers needed for promotion, which drive the actual operating strength, are derived from authorizations documents available 2 months earlier. Authorizations documents change every month, with accentuated changes every 6 months. Reports of actual fill will become poorer, as differences increase between actual and projected fill, due to changes in the authorizations documents.

(5) Insufficient Eligible Soldiers and Overfill. Too few soldiers eligible for promotion ("insufficient eligibility pool") or prior existence of overfill introduce additional complexity which is unrelated to target generation and which can obscure the effectiveness of a given target.

(6) Limitations of the Study. Identification of an improved target generation process general to all enlisted systems would be ideal. Because, of many complexities which have just been identified as characteristic of the E5/E6 promotion system, evaluation of target generation methodology in this study may be expected to be limited to the E5/E6 promotion system.

2-5. THE STUDY OBJECTIVES. The following objectives have structured the study:

a. Evaluate the effectiveness of the current target generation process based on the measurement of fill (operating strength relative to authorized strength) of enlisted grades E5 and E6 over all MOS and over time.

b. Develop and evaluate alternate methods of target generation based on the measurement of fill (operating strength relative to authorized strength) of enlisted grades E5 and E6 over all MOS and time.

2-6. THE STUDY SCOPE. The objectives are evaluated on the basis of the study scope specified as follows.

a. This study will be limited to examination of analytical modifications pertaining to the target generation process of the current E5/E6 promotion system.

b. Examination of the current and modified E5/E6 promotion system will be based on 12 consecutive simulations of the system for the 12 most recent months of available data (February 1987 - January 1988) for all MOS in grades E5 and E6 common to the 12 months of analysis (265 MOS, grade E5, and 242 MOS, grade E6).

c. Evaluations of the current system and modifications to the current system are based on fill (operating strength relative to authorized strength). Different variations in the measurements of fill which will be applied to this study are:

- Numbers of MOS in different categories of fill.
- Strength in different categories of fill.
- Magnitude of understrength (the number of soldiers who are needed to fill MOS, over all MOS for which operating strength is less than target strength).
- Magnitude of overstrength (the number of soldiers who exceed target strength, over all MOS for which operating strength is greater than target strength).

Categories of fill (as defined by the Army Enlisted Personnel Management Plan (EPMP), FY 1987 - FY 1991) which will be applied to this study are:

- Number of critically imbalanced MOS, underfill:
  fill < = .80

- Number of moderately imbalanced MOS, underfill:
  .80 < fill < = .95

- Number of balanced MOS:
  .95 < fill < = 1.05

- Number of moderately imbalanced MOS, overfill:
  1.05 < fill < = 1.20

- Number of critically imbalanced MOS, overfill:
  fill > 1.20

2-7. SOURCE DATA. The most recent 12 months of historical authorizations and targets as referred to in the study scope were available from February 1987 through January 1988. General Research Corporation (GRC) provided this data which contains the 84 months of authorization projections for each MOS/grade for every month. This data contains six stages: (1) PAM authorizations, (2) intermediate targets after SIMOS plus-up, (3) intermediate targets after smoothing, (4) intermediate targets after normalization to ELIM operating strength, (5) intermediate targets after THS inflation, and (6) final targets after grade limitations have been applied. Two additional types of supporting data were TAPA Promotion Model output and MOSLS historical strengths, gains, and losses.

a. TAPA Promotion Model Data. The Total Army Personnel Agency (TAPA), provided data containing the E5/E6 promotion model output for the period February 1987 to January 1988 for each MOS by month. This model output was used to reproduce historical projections of operating strength, numbers needed for promotion, final values of the promotion determination, and the monthly promotion ceilings.

b. MOSLS Historical Strengths, Gains, and Losses. GRC also provided data on trained strength (operating strength + THS), actual operating strength, and actual promotions. Promotions into grades E5 and E6 were obtained by using promotions out of grades E4 and E5 for the same MOS. However, from time to time, the Army conducts conversions and promotions-out from a lower grade may not be equal to promotions-in to the next higher grade in the same MOS. The data was examined for these conversions for the timeframe February 1987 - January 1988. During this timeframe, only three cases of conversions were found. These were considered as anomalies and the database was corrected by hand.

2-8. TIMEFRAME. February 1987 through January 1988.

2-9. ASSUMPTIONS. The key assumptions are as follows:

a. The simulation of the E5/E6 promotion system based on 12 months of the most recent available data within FY 1987-1988 will be sufficient for evaluation purposes.

b. Authorization patterns are sufficiently regular over time to permit effective application of statistical forecasting/smoothing techniques to the target generation process.

2-10. ESSENTIAL ELEMENTS OF ANALYSIS. Six questions were formulated which refer to analyses developed for the purpose of meeting the study objectives.

a. How do targets, as currently generated, compare with authorizations based on the measurement of fill (operating strength relative to authorized strength) for all MOS, for enlisted grades E5 and E6, over time?

b. What are the characteristics of those authorization patterns that produce large differences between operating strength, targets, and authorizations?

c. What is the most effective method of generating targets for each pattern?

d. If smoothing of the authorizations is appropriate, when in the target generation process should it be performed?

e. How do alternative target generation processes compare with the current process based on the measurement of fill, for each MOS and grade pair for grades E5 and E6 over time?

f. What are the effects of incorporating consideration of the availability of the soldiers eligible for promotion, the existence of overfill, the protection of space imbalanced MOS (SIMOS), and other constraints on fill, for each MOS at grades E5 and E6, over time?

2-11. ORGANIZATION OF THE STUDY REPORT. Study methodology is presented in Chapters 3 and 4. Chapter 3 describes alternative methods of generating targets, and Chapter 4 describes the simulation of the E5/E6 promotion system on which evaluation of alternate methods of target generation is based. Description of analyses, results, and findings which support each EEA are presented in separate chapters (Chapters 5-10). General insights and observations developed during the study are in Chapter 11.

2-12. SUMMARY. Background which led to initiation of the E5/E6 Target Generation Study (TARGEN) and the formulation of the study has been presented in this chapter.

CHAPTER 3

METHODOLOGY: TARGET GENERATION PROCESSES

3-1. INTRODUCTION

a. Target generation was introduced in Chapter 2 as a six-stage computational process. Smoothing of authorizations to remove abrupt fluctuations occurs at stage 3. Initially in the TARGEN Study, alternate methods of target generation referred to the examination of alternate smoothing techniques, primarily applied to the stage 2 authorizations. Because emerging results were different than originally expected, the concept of a target method was generalized to refer to the total sequence of computational stages and to variations of that sequence. The term "target generation process" replaced "target method" to emphasize the importance of considering the total sequence of computational stages. Smoothing techniques within any process were, of course, still of interest.

b. For the purpose of this study, historical promotion data was collected for the period beginning February 1987 through January 1988. During this period, the statistical smoothing technique was changed from double exponential smoothing to a weighted moving average which will be described below. Section I of this chapter provides a general description and graphical illustration of the alternate statistical smoothing techniques. Appendix D provides a more technical description of the techniques as needed. Section II describes the different computational sequences which are used to create targets. Section III briefly describes the methodology used to compare different target generation processes.

Section I. ALTERNATE STATISTICAL SMOOTHING TECHNIQUES

3-2. FIVE-POINT WEIGHTED MOVING AVERAGE. This is the current technique being used in the target generation process. This technique places emphasis at the end of the fiscal year because it was once felt that year-end authorizations had been more closely scrutinized. For those months not involving the fiscal year end (FYE) points (Dec-Jun), targets are calculated using equal weights, thus calculating a simple five-point moving average. For those months involving the FYE point, a five-point weighted average is calculated using the weights in Table 3-1.

Table 3-1. Weighted Values

Target month	Weighted months								
	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
July	.75	.75	.75	.75	2	-	-	-	-
August	-	.5	.5	.5	3	.5	-	-	-
September	-	-	0	0	5	0	0	-	-
October	-	-	-	0	3	.75	.75	.5	-
November	-	-	-	-	2	.75	.75	.75	.75

An example of this method is shown in Figure 3-1 using 11B E5 for the target month of November 1987.

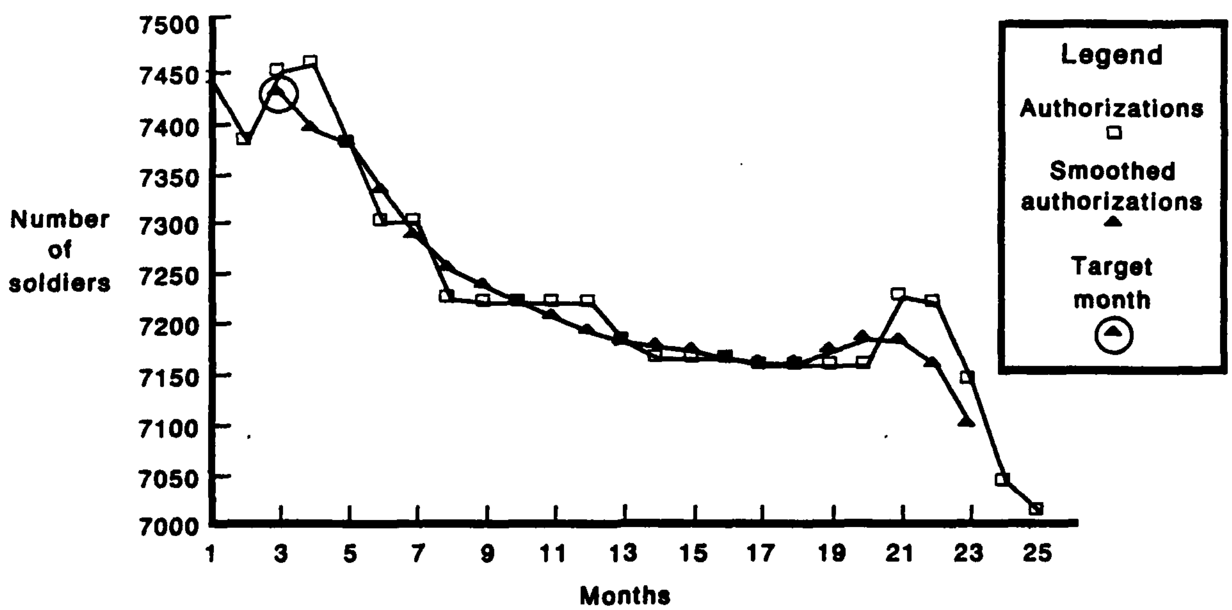


Figure 3-1. Five-point Weighted Moving Average
11B E5 Target Month = 8711 (3d month)

3-3. TUKEY-RIFFENBERG

a. This technique assumes that a series is made up of two parts: a smooth component and a rough component. The algorithm starts by smoothing a series to get the smooth component. This smoothing is done as a sequence of "smoothing by medians of 3" and "Hanning." "Smoothing by medians of 3" is finding the median of each triplet from consecutive moving groups of threes throughout the series. "Hanning" is a smoothing technique which replaces each value in the series by a percentage of itself and its neighbors. A further explanation of "smoothing by medians" and "Hanning" can be found in Appendix D.

b. The smooth component is then subtracted from the original series to get the rough component, which is in turn smoothed by "medians of 3" and "Hanning," creating a "smooth of the rough." This is then added back to the smooth component giving the "smoothed of the smooth." An example is shown in Figure 3-2 using 11B E5 for the target month of November 1987.

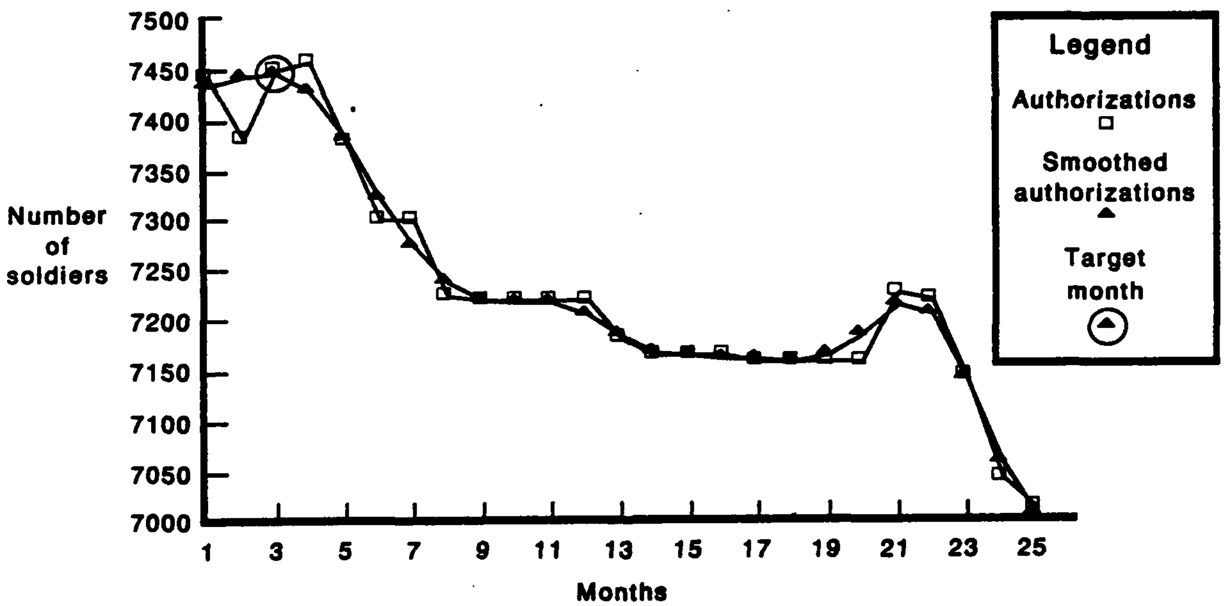


Figure 3-2. Tukey-Riffenberg Technique 11B E5 Target Month = 8711 (3d month)

3-4. WINTERS-HOLT. Winters-Holt is an exponential smoothing technique with a multiplicative seasonal factor that has different smoothing parameters to account for the level, trend, and seasonal component. Exponential smoothing means that the emphasis is placed on the most recent data and the importance of the data decreases exponentially with time. To obtain the starting values for level and trend, a linear regression is performed with time as the independent variable. These values are then updated each period, giving more weight to recent data. Smoothing constants are used to combine previous estimates of parameters with their updated values. This is the only technique which uses the complete set of monthly authorizations data. Emphasis has been placed on the future authorizations by looking at the series from the reverse direction. An example is shown in Figure 3-3 using 11B E5 for the target month of November 1987. A more technical description of this technique can be found in Appendix D.

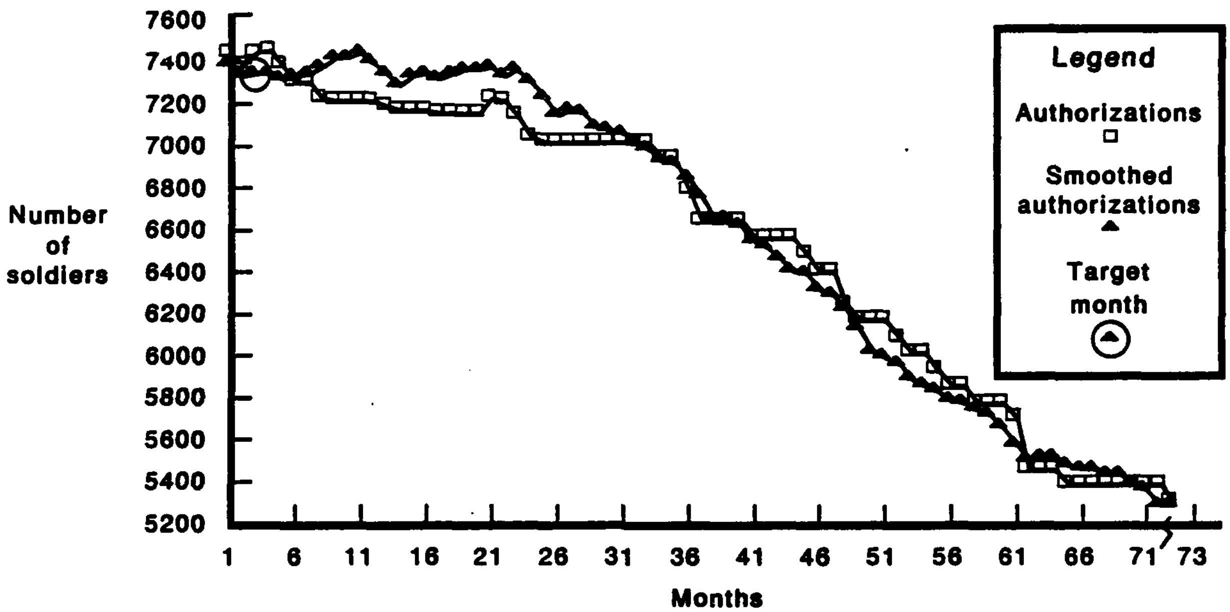


Figure 3-3. Winters-Holt Technique
11B E5 Target Month = 8711 (3d month)

3-5. REMOVAL OF OUTLIERS

a. An outlier has been defined as "an observation, or set of observations, which appear to be inconsistent with the remainder of that set of data." "Inconsistent" has been defined as a point in which the data increases (decreases) by greater than the maximum rate of change and then within a 3-month time period decreases (increases) by greater than the maximum rate of change. The maximum rate of change is determined as a function of MOS size, with larger rates for smaller size MOS and smaller rates for larger size MOS. Further explanation of the maximum rate of change can be found in Appendix D.

b. After identification of the outliers, two techniques have been used to accommodate them. The first technique uses a five-point moving average to smooth the outliers. The second technique uses a straightline approach from the adjacent points. An example is shown in Figure 3-4 using 91G E6 for the target month of September 1987. Note that based on the location of the outliers, the removal of outliers method may or may not have an effect on the target month.

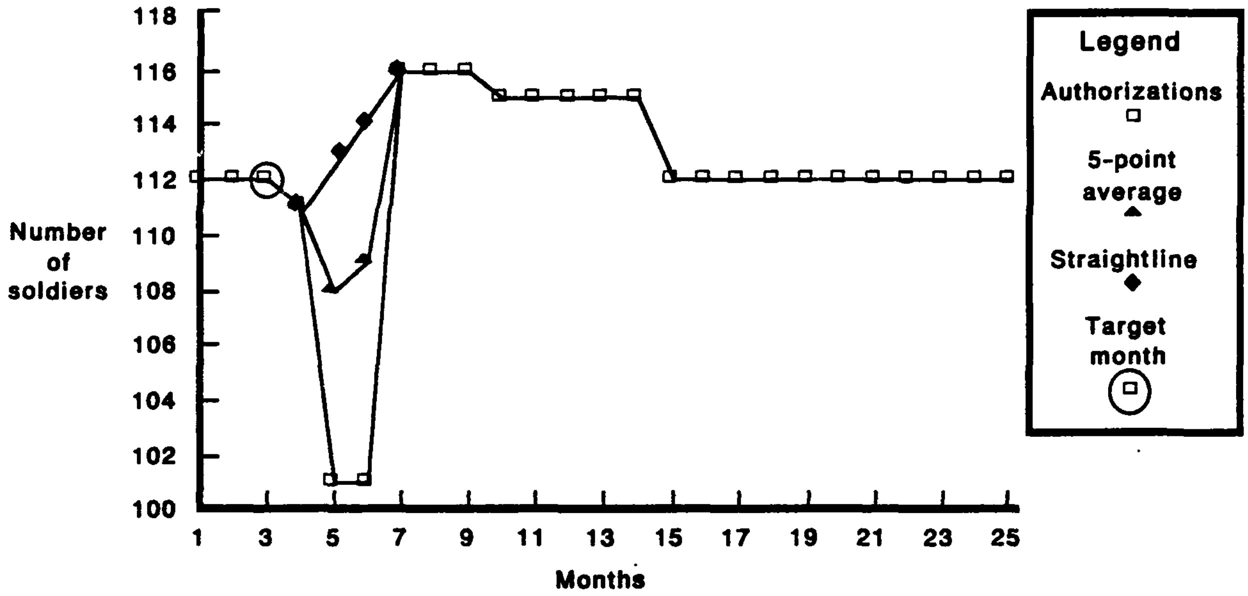


Figure 3-4. Removal of Outliers
91G E6 Target Month = 8709 (3d month)

3-6. RAMP

a. This technique first employs the technique of removing outliers using the straightline approach as described above. Next, steps are identified within the series. A step is defined as a point where the data increases (decreases) by greater than the maximum rate of change, calculated as a power function of the mean of the authorizations, and then does not decrease (increase) by greater than the maximum rate of change within a 3-month time-period.

b. This technique builds ramps to accommodate the step functions. The ramps are built so that there is neutral manning. That is, the amount of over (under) manning at the beginning of the ramp for increasing (decreasing) authorizations should be equal to the under (over) manning at the end. When there is a stepup (i.e., increase in authorization), targets are generated by first finding the midpoint of the step then adjusting the preceding and succeeding months based on the maximum rate of change and the number of preceding months. When a stepdown occurs, targets are generated using the same procedure; however, instead of using the maximum rate of change, a loss rate (provided by DCSPER) is used for each MOS and grade. An example is shown in Figure 3-5 using 96B E5 for the target month of February 1987.

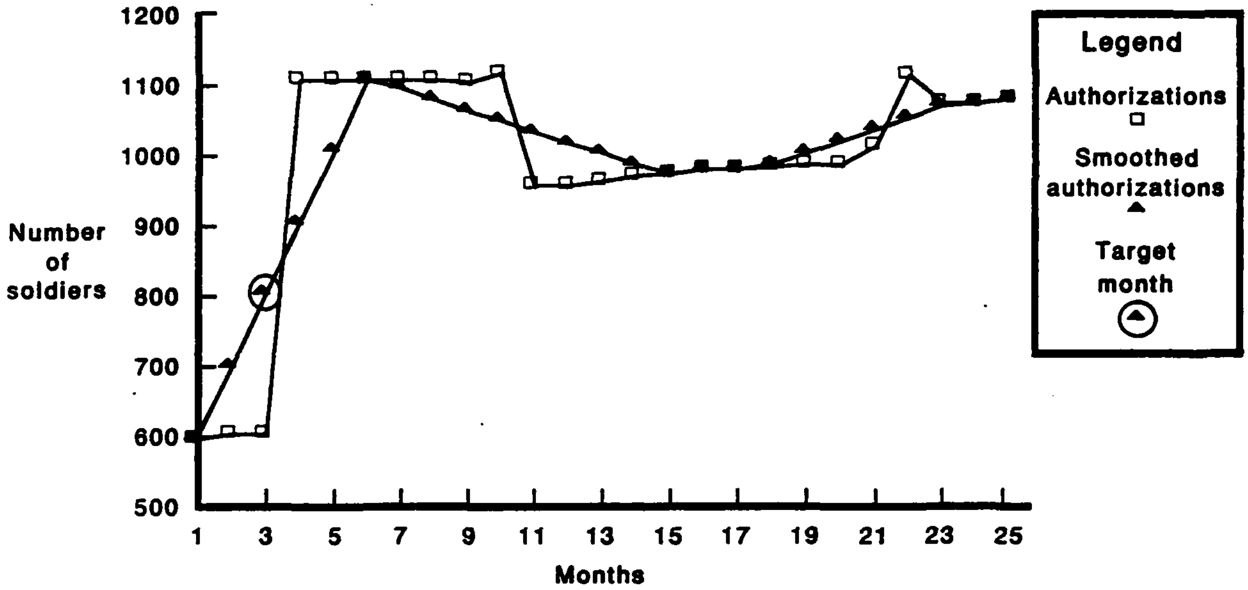


Figure 3-5. Ramp Technique
96B E5 Target Month - 8702 (3d month)

3-7. **TUKEY PLUS OUTLIER.** This technique is a combination of two of the previous techniques. The Tukey plus outlier technique first employs the technique of removing outliers using the straightline approach as described in paragraph 3-5. Then, the Tukey-Riffenberg technique is applied to these new authorizations. Whether or not this technique differs from the Tukey-Riffenberg technique is strictly dependent on the location of the outliers.

Section II. ALTERNATE TARGET GENERATION PROCESSES

3-8. **TYPES OF TARGETS.** Five different computational sequences which were used to create different types of targets are represented as paths in Figure 3-6.

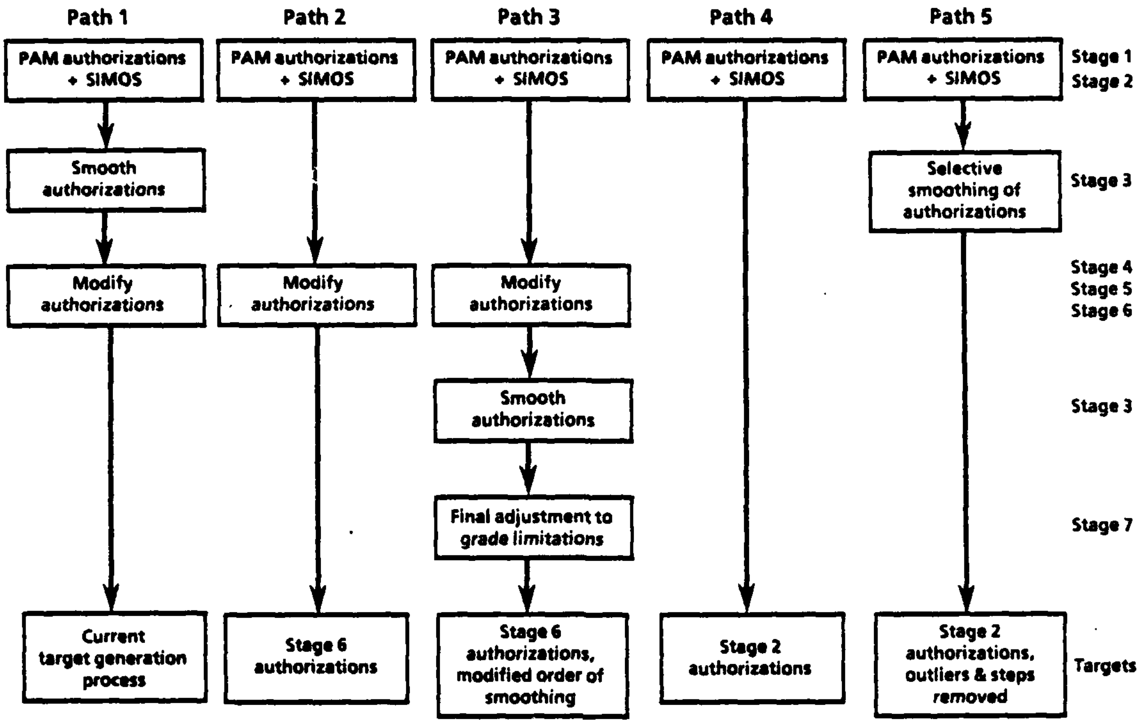


Figure 3-6. Target Generation Processes

a. **Stage 6 Targets.** The first path in Figure 3-6 represents the current target generation process. Smoothing occurs to the stage 2 authorizations; inflation of authorizations to strength projections, incorporation of trainees, holdees, and students (THS), and constraints to grade limitations occur respectively as stages 4, 5, and 6. Variation of target methods within this type of method refers to different applications of statistical smoothing techniques applied to the stage 2 authorizations.

b. **Stage 6 Authorizations.** The second path in the figure is identical to the first path, except that the smoothing step is eliminated. Stage 2 authorizations are moved directly through computational stages 4, 5, and 6 and are referred to subsequently as "stage 6 authorizations."

c. **Smoothed Stage 6 Authorizations.** Smoothing is again referred to in path 3, except that it is stage 6, not stage 2, authorizations which are smoothed. Because smoothing changes authorization sums, a final constraining stage (stage 7) establishes total authorized grade limitations. Variations of target methods within this type of method are created by different applications of statistical smoothing techniques.

d. **Stage 2 Authorizations.** Path 4 represents suppression of computations subsequent to stage 2. Numbers needed for promotion in the E5/E6 promotion system are determined by comparing operating strength with the stage 2 authorizations. Constraints on total numbers of authorizations constraints are transformed to constraints on total numbers of promotions within the analytical framework of the E5/E6 promotion system.

e. **Smoothed Stage 2 Authorizations.** Path 5 represents a variation from path 4 only in application of statistical smoothing techniques to the stage 2 authorizations.

Section III. COMPARING TARGET GENERATION PROCESSES

3-9. COMPARISONS OF TARGET GENERATION PROCESSES. Comparisons of target processes are based on the measurement of fill (operating strength/authorized strength) derived from simulations of the E5/E6 promotion system. The five types of target generation processes are illustrated in Figure 3-7 as alternate inputs to the E5/E6 promotion system. Figure 3-7 represents the major impact of the target as determining numbers needed for promotion. A more detailed description of subsequent stages of the simulation, which tracks accumulated changes in operating strength that would occur in the E5/E6 promotion system if different targets were applied to the system, is the subject of Chapter 4.

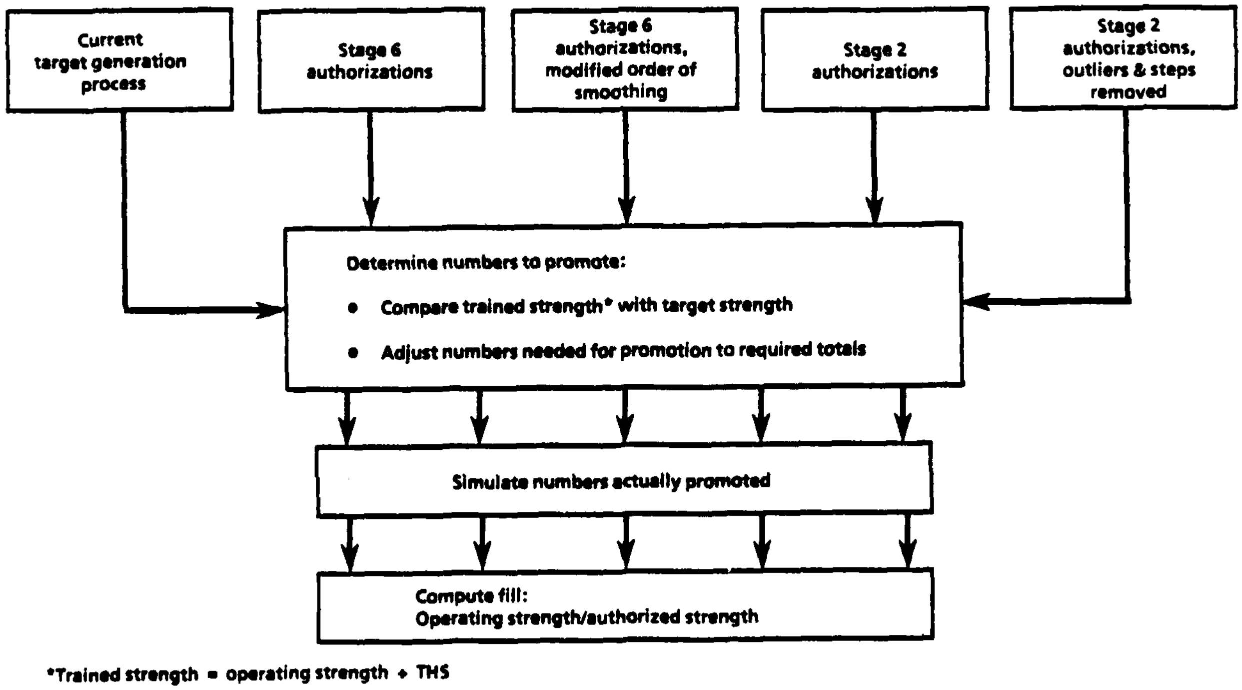


Figure 3-7. Comparing Target Generation Processes

3-10. CHAPTER SUMMARY. The structure of the alternate target generation processes has been presented in this chapter. Descriptions of the alternate smoothing techniques, as well as the different computational sequences used in the target generation process have been presented. Comparing the alternate target generation processes was briefly described as a lead-in to the next chapter.

CHAPTER 4

METHODOLOGY: SIMULATION OF THE E5/E6 PROMOTION SYSTEM

4-1. INTRODUCTION. Evaluation of alternate target generation processes in this study is based on simulation of the E5/E6 promotion system, measuring accumulated changes in operating strength to reflect alternate targets, and the computation of fill (simulated operating strength divided by authorized strength). Values of fill vary, of course, when different versions of the authorizations are used to compute fill, and when different conditions in the E5/E6 promotion are simulated. The purpose of this chapter is to establish a baseline for all subsequent analyses. Secondarily, results are provided which identify computations and portions of the E5/E6 promotion system which must strongly impact on fill.

4-2. THE SIMULATION. The following computational steps accumulate the changes in strength over 12 months of simulation to measure the effects of a given target.

a. For every MOS in grades E5 and E6 compute:

numbers needed for promotion = target (stage 6) - trained strength

b. Constrain numbers needed for promotion to the "promotion determination." The sum of promotion determination over all MOS for a given grade and month is the historical promotion ceiling.

c. Simulate numbers actually promoted: Modify the promotion determination by historical difference between promotion determination and actual numbers promoted.

d. Cumulate changes in trained strength from the previous month to the target month. Trained strength (target month) = trained strength (previous month) + historical gains and losses other than promotions - actual promotions + simulated promotions.

e. Compute: operating strength = trained strength - THS

f. Compute fill: operating strength/authorized strength

4-3. ESTABLISHING A BASELINE. To show the impact that creating an increasingly ideal E5/E6 promotion system would have on fill, as well as to establish the baseline for subsequent analysis, histograms reflecting of different components of the system are displayed in order of increasing percentages of balanced MOS (Figures 4-1, E5, and 4-2, E6). The eight bars in each figure are discussed separately.

a. **Bar 1.** Percentage of balanced MOS in the first bar represents a reproduction of the historical promotion system, as it existed in Feb 87 - Jan 88, with fill being evaluated with a different authorizations document than the document used to determine numbers needed for promotion.

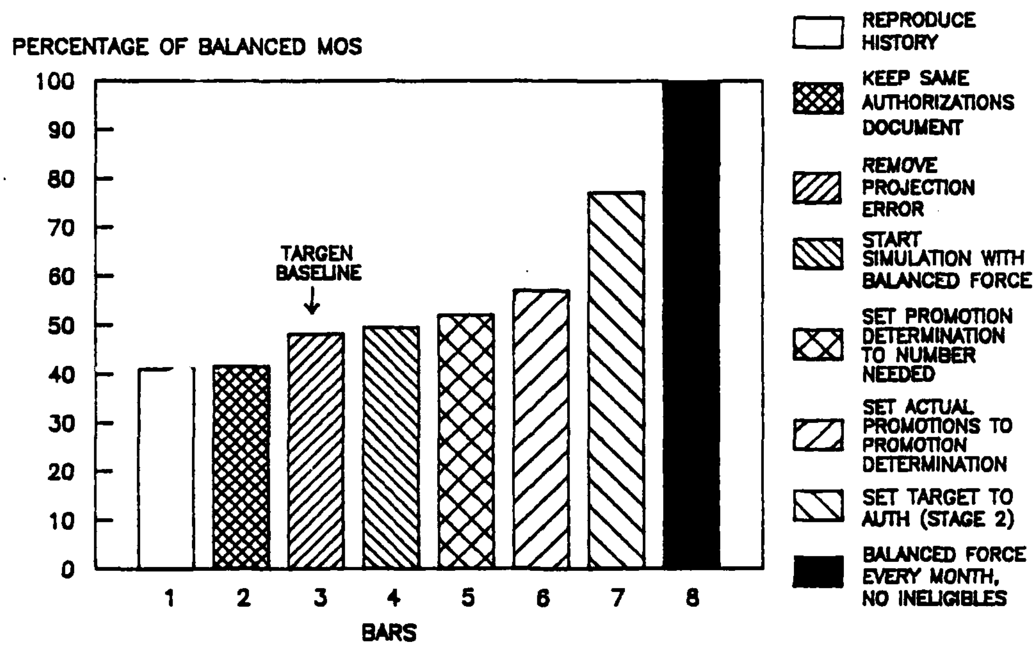


Figure 4-1. Simulating Changes to the E5/E6 Promotion System, Grade E5

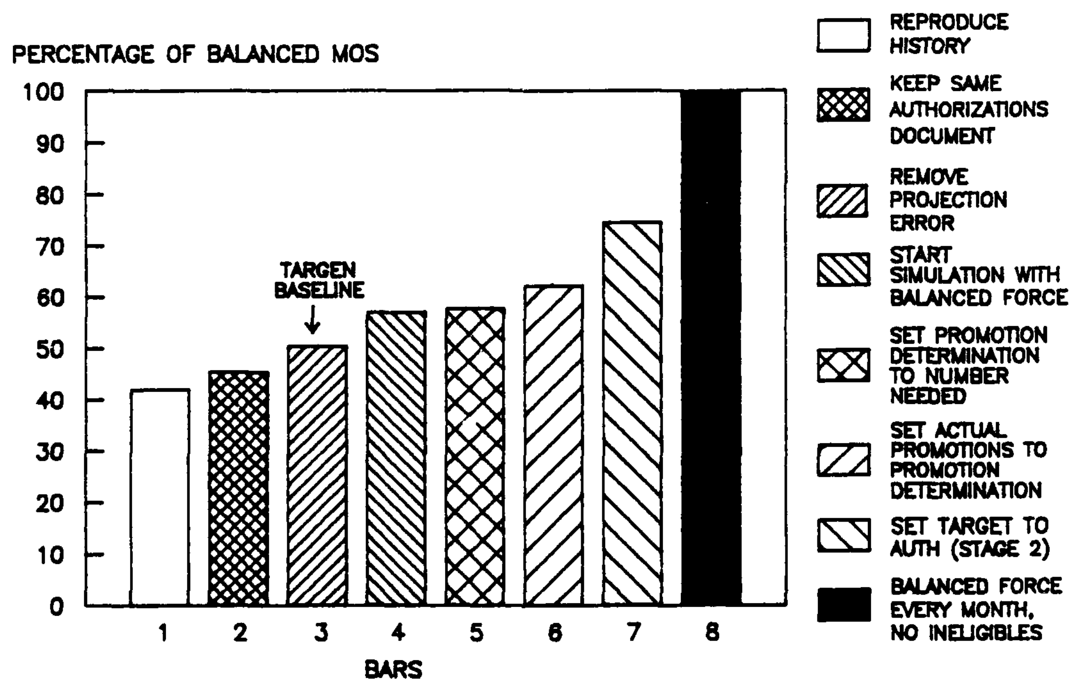


Figure 4-2. Simulating Changes to the E5/E6 Promotion System, Grade E6

b. **Bar 2.** In the second bar, the same authorizations document is used to determine numbers needed for promotion and to evaluate fill. Percentage increase in fill from bar 1 to bar 2 is 0.6 percent for grade E5 and 3.5 percent for grade E6.

c. **Bar 3.** Percentages of balanced MOS, bar 3, reflects a promotion system in which promotions are determined relative to actual numbers needed, rather than to projections of numbers needed. Percentage increase in fill from bar 2 to bar 3 is 6.6 percent for grade E5 and 5.0 percent for grade E6.

d. **Bar 4.** In the fourth bar, overstrength and understrength existing at the start of the simulation are removed by setting operating strength to authorized strength in every MOS at the starting month of the simulation. Percentages of balanced MOS increase by 1.3 percent for grade E5 and by 6.6 percent for grade E6.

e. **Bar 5.** The fifth bar shows percentages of balanced MOS when the constraining process of reducing numbers needed for promotion to historical ceilings is removed. Setting the promotion determination equal to numbers needed results in an increase of balanced MOS from bar 4 to bar 5 of 2.5 percent for grade E5 and 0.6 percent for grade E6.

f. **Bar 6.** The promotion determination directly drives actual promotions. Yet numbers of actual promotions do not exactly equal the promotion determinations (Figures 2-6 and 2-7). Percentages of balanced MOS, bar 6, represent a promotion system in which actual promotions do exactly equal the promotion determinations. An increase of 4.9 percent balanced MOS occurs for grade E5 and 4.5 percent for grade E6.

g. **Bar 7.** Percentages of balanced MOS, bar 7, represent a system in which targets historically generated are replaced by stage 2 authorizations. Consequently, numbers needed for promotion are both determined and evaluated relative to the same target criterion (the stage 2 authorizations). Increases in percentage of balanced MOS from bar 6 to bar 7 is 20.2, grade E5, and 12.4 for grade E6.

h. **Bar 8.** This represents a promotion system in which no overstrength nor understrength exists in any month, and promotions are both determined and evaluated with response to the same target (the stage 2 authorizations). The percentage of balanced MOS is computed to be 100 percent for both grades E5 and E6.

i. In summary, changes in authorizations documents and error due to projections of total strength create noise which could obscure the effects of target generation methodology (bars 1 and 2). To evaluate the effects of starting the simulation with a balanced force, removing constraints on numbers promoted, and setting promotion determinations to actual promotions (bars 4, 5, and 6), special analyses were performed later in the study. The baseline for the majority of study analyses, however, was set at that simulation of the E5/E6 promotion system represented by bar 3: that is, numbers needed for promotion are determined relative to actual strength, not projected strength, and both determinations of promotions and evaluations of those determinations are derived from the same authorizations.

4-4. DIFFERENT COMPUTATIONS OF FILL. Values of fill also vary with additional types of computations. Listed below are six different computations. (The month for which numbers needed for promotion are being determined is referred to as the "target month.")

1) Fill = Operating Strength/Authorization (Stage 1)
   (Using authorizations document known at target month + 2)

2) Fill = Operating Strength/Authorization (Stage 2)
   (Using authorizations document, target month + 2)

3) Fill = Operating Strength/Authorization (Stage 1)
   (Using authorizations document, target month)

4) Fill = Operating Strength/Authorization (Stage 2)
   (Using authorizations document, target month)

5) Fill = Operating Strength/Authorization (Stage 4)

6) Fill = Operating Strength + THS/Authorization (Stage 6)

Figures 4-3 and 4-4 display computations based on the actual E5/E6 promotion system and the simulation of the actual system. The computation for which TARGEN results are established is the fourth computation: operating strength relative to the stage 2 authorized strength. The exception is for analyses which involve change in authorizations document (Chapter 5). For such analyses, computation 2 is used.

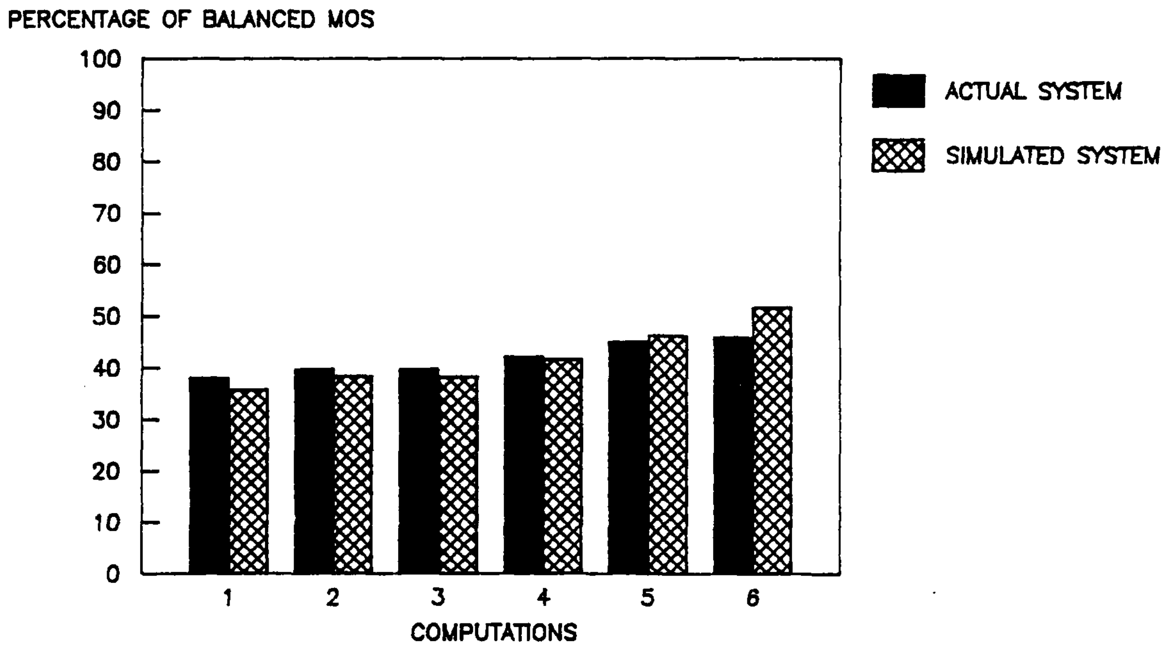


Figure 4-3. Computations in the E5/E6 Promotion System Which Affect Fill (8702 - 8801): Grade E5

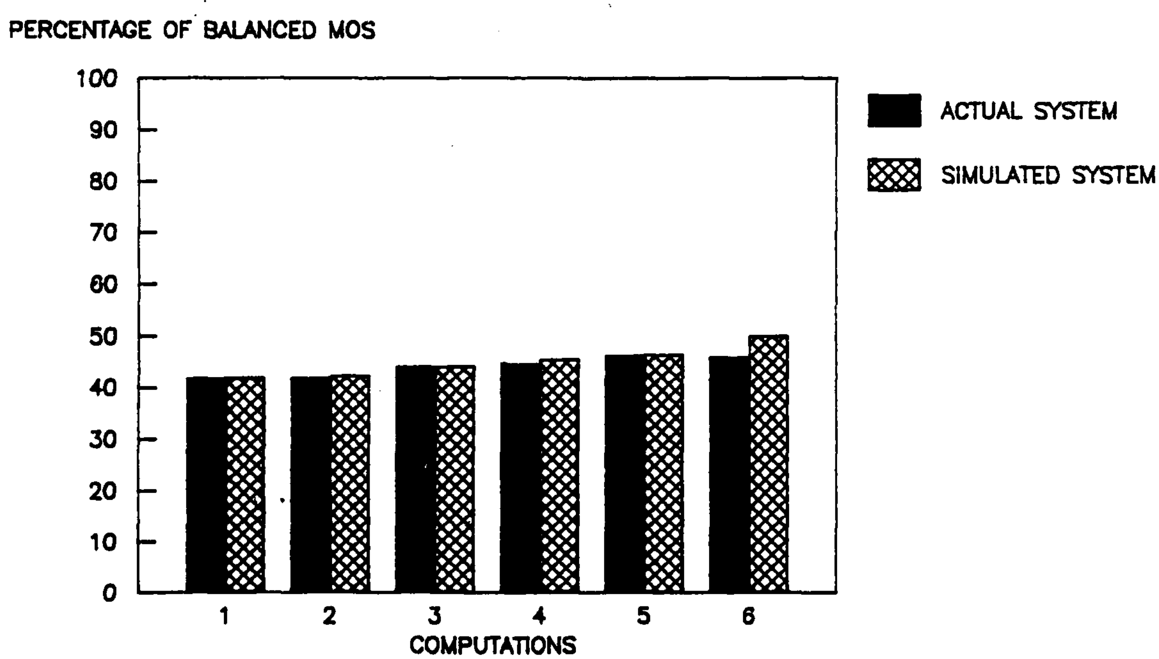


Figure 4-4. Figure 4-3. Computations in the E5/E6 Promotion System Which Affect Fill (8702 - 8801): Grade E6

4-5. ADDITIONAL COMPARISONS OF ACTUAL AND SIMULATED RESULTS

a. Percentages of balanced MOS were used in Figures 4-3 and 4-4 to compare differences between actual and simulated results. Tables 4-1 through 4-4 show comparisons using percentages of MOS in all 5 categories of fill and average number of shortages and overages per month for each grade. Two different types of simulations are compared with the actual system. In the first, numbers needed for promotion are determined relative to projected operating strength, as occurs in the actual system; in the second simulation, the projection error is removed.

b. Compared with the actual system, the effect of the simulation most similar to the actual system (i.e., promotions determined relative to projected, not actual, strength), was to reduce percentage of MOS in the critically imbalanced categories by 1 to 4 percent, to increase the percentage of balanced MOS by about 1 percent, and to increase the percentage of MOS in the critically imbalance MOS, overfill by 1 to 3 percent. The tendency for the simulation to decrease shortages and to increase overages is also shown again in Tables 4-3 and 4-4 of average number of shortages and overages per month. The effect of the simulation with projection error removed is to reduce percentages of MOS in categories of underfill, to increase percentages of balanced MOS, and to reduce percentages of critically imbalanced MOS, overfill. Average numbers of shortages and overages are also reduced for the more ideal simulation, but average number of overages per month still exceeds overages existing in the actual system.

c. Differences occur between the actual and simulated systems to account for differences in results.

(1) Computing Numbers Needed for Promotion. For the actual system, projected numbers needed for promotion are read directly from historical records developed by the Total Army Personnel Agency (TAPA) in determining E5/E6 promotions. For the simulated system, numbers needed for promotion are computed as the difference between trained strength and the stage 6 target reproduced from actual history.

Table 4-1. Comparing Actual and Simulated Promotion Systems
Percentage of MOS in Categories of Fill (8702-8801)

Grade E5

Target process	Category of fill					
	Critically under	Moderately under	Balanced	Moderately over	Critically over	Total
Actual E5/E6 promotion system	10	23	42	14	11	100
Simulated E5/E6 promotion system	7	21	42	17	13	100
Simulated system, projection errors removed	4	23	48	14	11	100

Table 4-2. Comparing Actual and Simulated Promotion Systems
Percentage of MOS in Categories of Fill (8702-8801)

Grade E6

Target process	Category of fill					
	Critically under	Moderately under	Balanced	Moderately over	Critically over	Total
Actual E5/E6 promotion system	6	14	45	22	13	100
Simulated E5/E6 promotion system	5	10	46	25	14	100
Simulated system, projection errors removed	3	9	51	24	14	100

Table 4-3. Comparing Actual and Simulated Promotion Systems
Average Strength of MOS in Understrength and Overstrength (8702-8801)

Grade E5

Target process	Average strength	
	Understrength	Overstrength
Actual E5/E6 promotion system	-6,995	2,878
Simulated E5/E6 promotion system	-6,325	3,835
Simulated system, projection errors removed	-4,979	2,945

Table 4-4. Comparing Actual and Simulated Promotion Systems
Average Strength of MOS in Understrength and Overstrength (8702-8801)

Grade E6

Target process	Average strength	
	Understrength	Overstrength
Actual E5/E6 promotion system	-2,875	2,216
Simulated E5/E6 promotion system	-2,172	2,771
Simulated system, projection errors removed	-1,591	2,487

(2) **Constraining Numbers Needed.** In the actual system, final promotion determinations are read directly from TAPA E5/E6 promotion determination records. These records originate from an automatic computational procedure of reducing numbers needed for promotion to the required promotion ceilings in combination with ad hoc revisions of the promotion determinations by E5/E6 promotion specialists.

- For the simulated system, the reduction of numbers needed for promotion is totally automatic, but is developed to reproduce the TAPA automatic procedure. When trained strength is less than target strength, then numbers needed for promotion can be set to target strength and (numbers needed + trained strength)/target = fill = 1.00. To constrain numbers needed to sum to a promotion ceiling, values of fill are reduced successively by .01, solving for reduced numbers needed with each reduction in fill, until the sum of the reduced numbers needed reaches the promotion ceiling. The most recent available prioritization order of reducing MOS was followed in the CAA solution (although the prioritization list is actually changed by TAPA every month); existence of overfill or insufficient eligible soldiers was taken into account in the CAA solution as it is done at TAPA.

- To compare the CAA automatic procedure with the TAPA semiautomatic procedure, a "reduction error" measured magnitude of the reduction of numbers needed (nn) to promotion determinations (pd) relative to the size of the target. This reduction error = (nn - pd)/target was computed over all MOS in grade E5 and E6 for each of the 12 months of analysis, using actual and simulated results. The size of the reduction error was consistently lower for the CAA automatic procedure than for the TAPA semiautomatic procedure. The average reduction error per month was 16.15, TAPA, and 13.13, CAA, for grade E5; for grade E6, the average error was 9.21, TAPA, and 7.60, CAA.

(3) **Truncation of Promotions.** Actual promotions are different from the promotion determinations, and the historical difference is reproduced in the simulation. When the promotion determination is close to zero and the historical difference is in the direction of reduced actual promotions, then the total number of promotions will be truncated.

4-6. CHAPTER SUMMARY. This chapter describes the simulation of the E5/E6 promotion system, upon which evaluations of alternate target generation methods will be based. Results show the impact on fill for increasingly ideal simulations of the system, as well as for different computations of fill. A baseline was established for subsequent analyses. To evaluate alternate methods, actual operating strength rather than projected operating strength will be compared with the target. Fill will be computed as operating strength, relative to the stage 2 authorization, with no change in authorizations document.

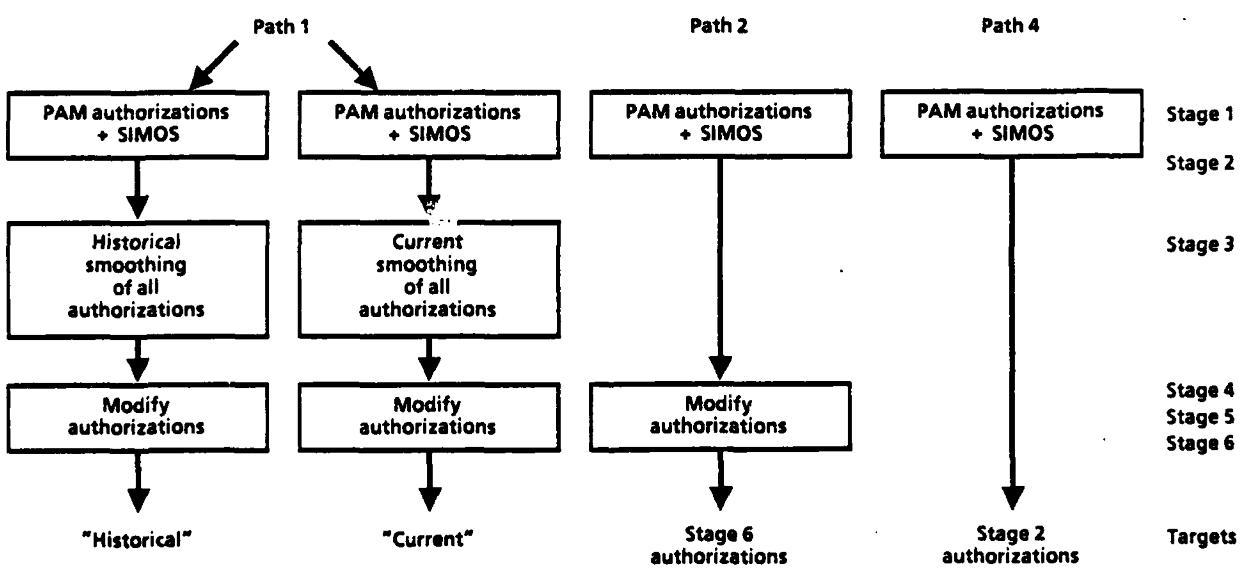
CHAPTER 5

EEA 1: ANALYSIS AND RESULTS

5-1. INTRODUCTION. The purpose of this chapter is to describe analyses and present results which address EEA 1: how do current targets compare with authorizations, based on measures of fill?

5-2. METHODOLOGY

a. In the comparison of current targets with authorizations two versions of current targets and two versions of authorizations must be considered. Target generation processes referred to in Figure 1-1 as paths 1, 2, and 4 are reproduced in Figure 5-1. Path 1 is expanded into two paths, "historical" and, again, "current." These two paths differ only by the statistical technique used to smooth authorizations in stage 3. "Historical" targets are recreated by reading from actual records used from February 1987 through January 1988. In the first 7 of the these 12 months, a double exponential smoothing technique was originally used to produce these targets; in the second 5 months (September-January) a five-point weighted moving average technique was used. "Current" targets refer to a recomputation to produce targets for all 12 months using the moving average technique.



Stage 4: Inflate to Army-wide strength projections
Stage 5: Incorporate Trainee, Holdees, and Students (THS)
Stage 6: Constrain to grade limitations

Figure 5-1. Methodology (EEA 1) - Authorizations and the Current Target Generation Process

b. Evaluation of the two versions of authorizations and the two versions of current targets based on simulation of the E5/E6 promotion system and computation of fill is illustrated in Figure 5-2.

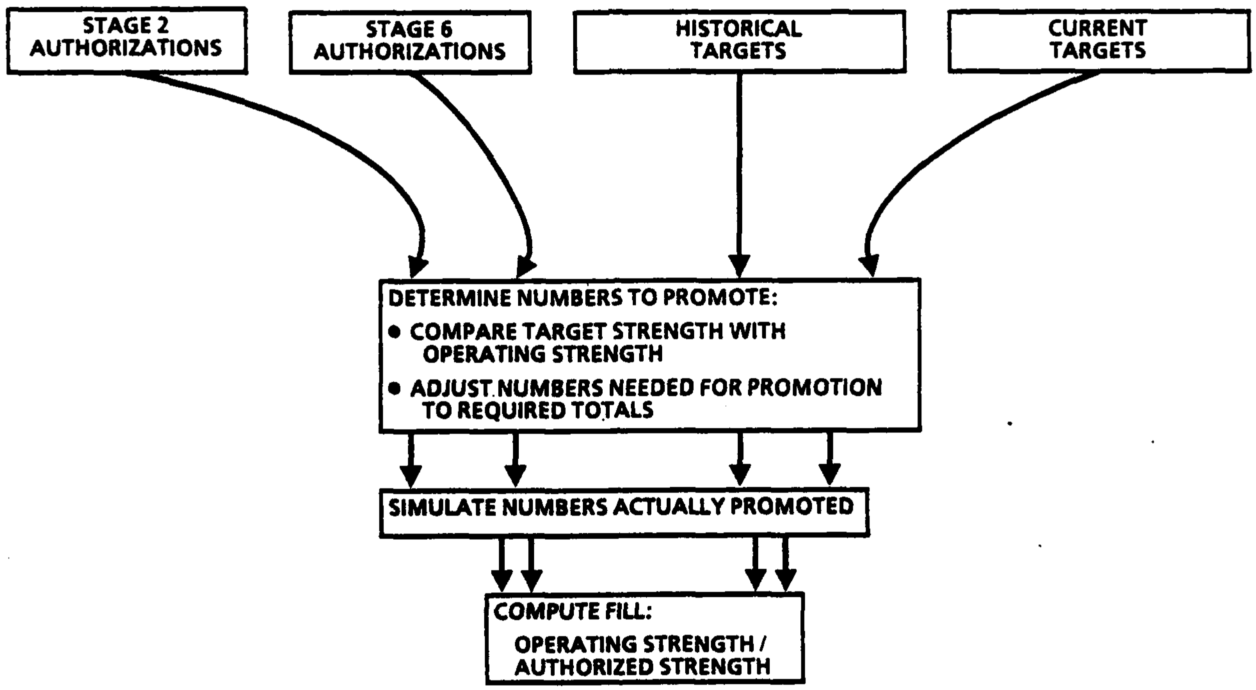


Figure 5-2. Methodology (EEA 1) - Comparing Authorizations and Current Targets

5-3. RESULTS

a. Format of Presentation

(1) Tabular results for the authorizations and current target methods are in the form of percentages of balanced MOS, average numbers of shortages per month, and average number of overages per month, computed over the 12 months of analysis (Tables 5-1 through 5-4). Tables containing monthly averages for all measures of fill (number, percentages, and strength of MOS in categories of fill, and number of shortages and overages) are in Appendix I (Tables I-33 through I-40).

Table 5-1. Comparison of Current Targets with Authorizations
Percentage of MOS in Categories of Fill (8702-8801), Grade E5

Target process	Category of fill					
	Critically under	Moderately under	Balanced	Moderately over	Critically over	Total
Historical	4	23	48	14	11	100
Current	4	20	52	14	11	100
Auth (stage 6)	4	19	53	13	11	100
Auth (stage 2)	7	11	58	14	11	100

- Best method (balanced MOS): auth (stage 2).
- Worst method (critically under MOS): auth (stage 2).
- Best method (distribution of fill): auth (stage 6).

Table 5-2. Comparison of Current Targets with Authorizations
Percentage of MOS in Categories of Fill (8702-8801), Grade E6

Target process	Category of fill					
	Critically under	Moderately under	Balanced	Moderately over	Critically over	Total
Historical	3	9	51	24	14	100
Current	3	8	54	23	13	100
Auth (stage 6)	3	7	54	22	14	100
Auth (stage 2)	3	5	57	22	13	100

- Best method (balanced MOS): auth (stage 2).
- Best method (distribution of fill): auth (stage 2).

Table 5-3. Comparison of Current Targets with Authorizations Average Strength of MOS in Understrength and Overstrength (8702-8801), Grade E5

Target process	Average strength	
	Understrength	Overstrength
Historical	-4,979	2,945
Auth (stage 2)	-5,141	2,796
Current	-4,721	2,715
Auth (stage 6)	-4,703	2,706

- Best method (understrength and overstrength): auth (stage 2)
- Worst method (understrength): auth (stage 2)

Table 5-4. Comparison of Current Targets with Authorizations Average Strength of MOS in Understrength and Overstrength (8702-8801), Grade E6

Target process	Average strength	
	Understrength	Overstrength
Historical	-1,591	2,487
Auth (stage 6)	-1,564	2,359
Current	-1,554	2,351
Auth (stage 2)	-1,522	2,329

- Best method (understrength and overstrength): auth (stage 2)

(2) Plots of percentages of balanced MOS are plotted for each of the 12 months of analysis in Figures 5-3 and 5-4.

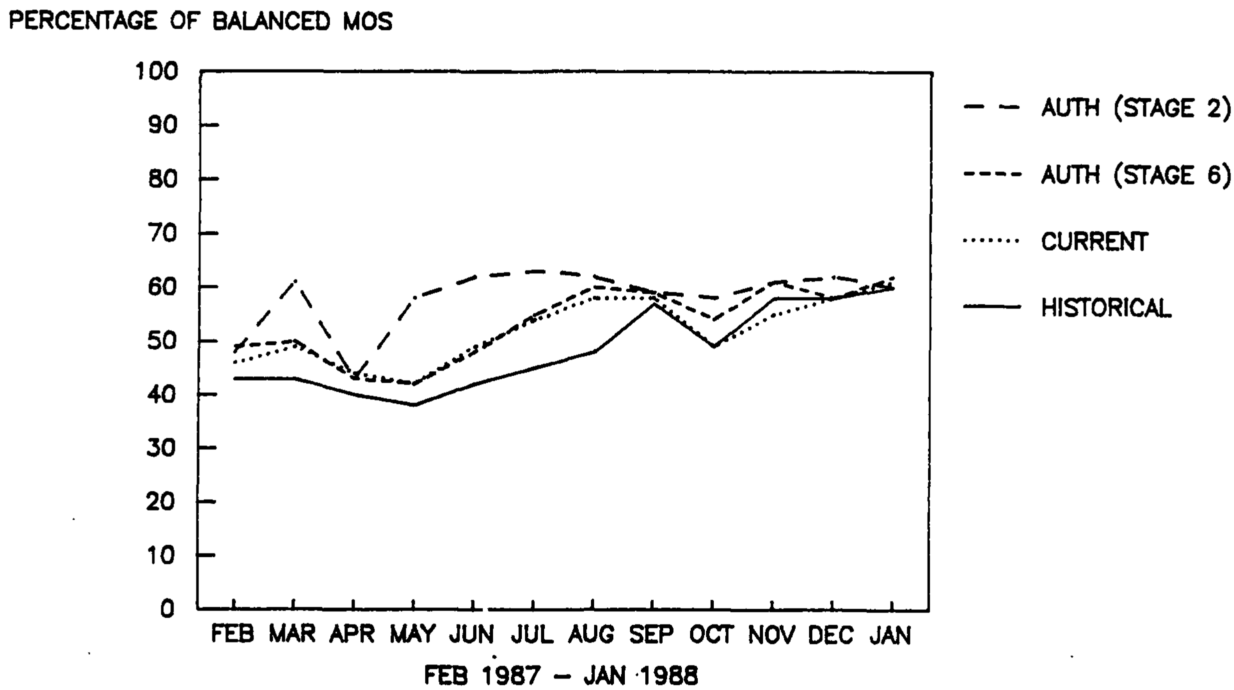


Figure 5-3. Comparing Current Targets with Authorizations, Grade E5

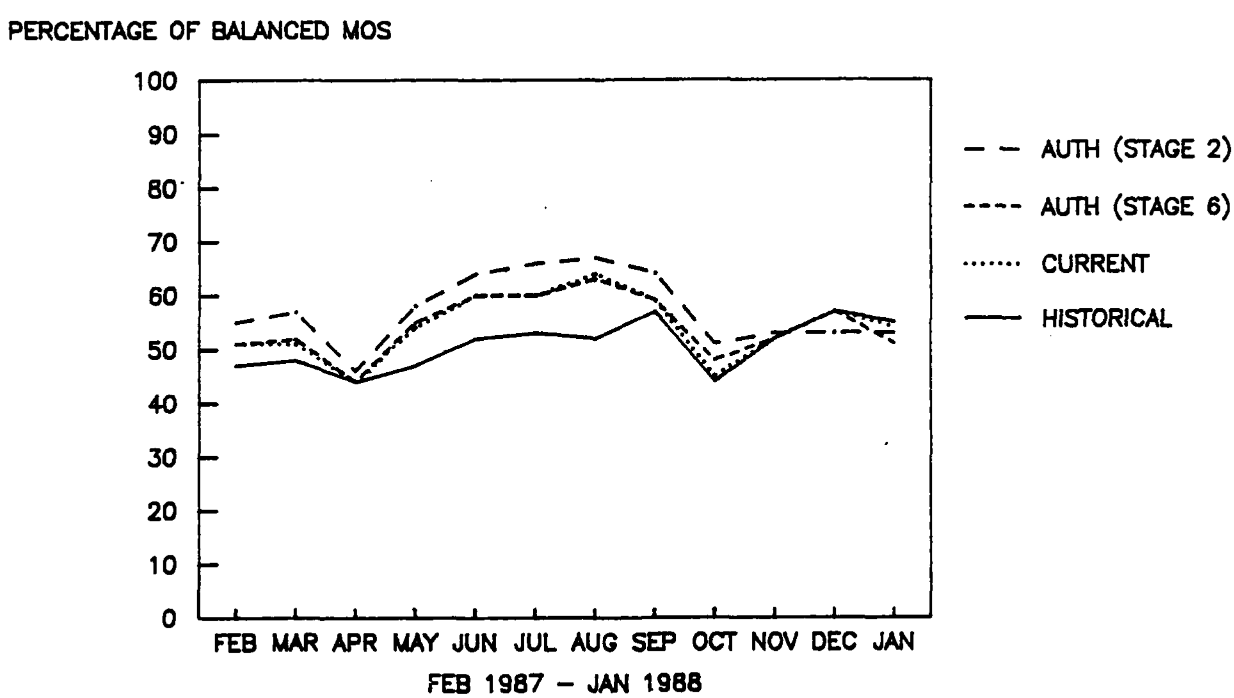


Figure 5-4. Comparing Current Targets with Authorizations, Grade E6

b. **Method of Interpretation.** Comparing target generation processes is based on multiple variations of fill. Ideally, an improved process will have (1) increased numbers/percentages/strength of MOS categorized as balanced, (2) decreased numbers/percentages/strength of MOS in categories of underfill or overfill, and (3) decreased numbers of shortages and overages. Realistically, a process which improves balance may shift imbalance from underfill to overfill (or vice versa). In evaluating the effects of the different processes, an effort is made to describe how the processes change the distribution of results with respect to balance/imbalance and shortages/overages. A process which improves balance but still accentuates underfill may be acceptable in one manpower environment, whereas a process which improves balance but accentuates overfill may be acceptable in another.

c. **Interpretation**

(1) The largest difference in percentage of balanced MOS occurs between the historical target generation process (48 percent) and the stage 2 authorization (58 percent), grade E5. The largest difference in percentage of balanced MOS, grade E6, also occurs between the historical target (51 percent) and the stage 2 authorization (57 percent). When percentages of balanced MOS are plotted by month (Figures 5-1, grade E5, and 5-2, grade E6), distinct bounds defined by highest percentages of the stage 2 authorization and lowest percentages of the historical processes become apparent. Percentages of balanced MOS plotted by month for all other processes in the study, with only a few exceptions, fall within these bounds. The exceptions which do occur are in the direction of slightly higher percentages of balanced MOS for variations of the stage 2 and stage 6 authorizations, to be reported later in the study.

(2) In grade E5, the stage 2 authorization does not maintain superiority when examining measures of fill other than percentages of balanced MOS. Increased percentages of critically imbalanced MOS, underfill (7 percent, compared with 4 percent, current process) are reported for the stage 2 authorizations as well as 420 more soldiers understrength and 81 more soldiers overstrength than for the current process (averages per month).

(3) The stage 6 authorization maintains more consistent superiority to the current target generation process, but this superiority is only slight. Stage 6 authorizations, relative to the current process, reduce percentages of MOS in categories of moderate underfill or moderate overfill by 1 percent (grades E5 and E6), and by 18 fewer shortages and 9 fewer overages (grade E5, overages per month). The stage 6 authorization is inferior to the current process by 10 soldiers understrength and by 8 soldiers overstrength in grade E6.

(4) The current target generation process is distinctly superior to the historical target generation process in all measures. In grade E5, the current process reduces percentages of MOS in categories of underfill or overfill by 3 percent (grade E5), 1 percent (grade E6), and increases percentages of balanced MOS by 4 percent (grade E5) and 3 percent (grade E6). Reduction in understrength is by 258 soldiers in grade E5 and by 37 soldiers in grade E6 (averages per month); overstrength is reduced by 230 soldiers, grade E5, and by 136 soldiers, grade E6 (averages per month).

(5) The magnitude of any of the differences reported between processes tends to be smaller for grade E6 than for grade E5.

5-5. RESPONSE TO EEA 1

a. Authorizations (stage 2) and authorizations (stage 6) are both better than the current and historical targets in terms of percentages of balanced MOS. The greater superiority, however, occurs for the stage 2 authorization relative to the current process (by 6 percent balanced MOS in grade E5 and by 3 percent balanced MOS in grade E6).

b. Superiority of authorizations (stage 2) is dampened in grade E5 by (1) critically imbalanced MOS, underfill and by (2) number of shortages and overages. A percentage increase of 3 percent critically imbalanced MOS, underfill, was reported for authorizations (stage 2), compared with any of the other processes (grade E5). Furthermore, an average of 420 more shortages per month and 81 more overages per month were observed for authorizations (stage 2) than for the current process (grade E5).

c. Current targets are distinctly superior to historical targets (by 4 percent balanced MOS, grade E5, 3 percent balanced MOS, grade E6) by fewer shortages (an average of 258 soldiers short per month, grade E5, and 37 soldiers short per month, grade E6) and by fewer overages (an average of 230 soldiers overstrength per month, grade E5, and 136 soldiers overstrength, grade E6). Implementation of the five-point weighted moving average in September 1987 was thus demonstrated to be a good decision.

CHAPTER 6

EEA 2: ANALYSIS AND RESULTS

6-1. INTRODUCTION. The purpose of this chapter is to describe analyses and present results which address EEA 2: what are the characteristics of those authorization patterns that produce large differences between operating strength, targets, and authorizations?

6-2. METHODOLOGY. The Army projects up to 84 months of authorizations of personnel strength by grade and MOS for each month. These projected authorizations exhibit distinct patterns which influence fill (operating strength relative to authorized strength). Before smoothing these patterns to project better authorizations, distinct patterns were categorized for their behavior by using different statistical methods. It was found that each category of distinct patterns influences the projected authorizations of personnel strength. In this chapter, a brief description of each distinct pattern and what effect it has on strength is discussed.

6-3. RESULTS

a. Format of Presentation. Results, based on the balanced category of fill, are presented for each pattern and their subcategories. When an "other" subcategory is shown, this accounts for the rest of the MOS not included in the mentioned subcategories. The average number of balanced MOS, percentage of balanced MOS, and average number of observations are presented for grade E5 of the current smoothing process based on the 12 months of analysis. Results for grade E6 are presented in Appendix H.

(1) Authorization Size. Technically, authorization size is not an authorization pattern; however, it was considered important since the categories of fill did not take size into consideration. Authorization size is number of soldiers in a MOS/grade in a particular month. It has a significant influence on the measure of fill. The smaller the density of an MOS, the larger the influence it has on fill. Four categories of MOS authorization size were considered. Table 6-1 indicates that out of 265 MOS per month in grade E5, an average of 23 MOS were in the less than 20 size category. Out of 23 MOS, only 22 percent were balanced. In the over 100 size category, 63 percent of the MOS were balanced.

Table 6-1. Impact of Authorization Size on Number of Balanced MOS, Grade E5

Authorization size	Average number of balanced MOS	Percent balanced MOS	Average number of observations
< 20	5	22	23
20 - 50	14	35	40
50 - 100	25	48	52
> 100	94	63	150
Overall	138	52	265

(2) **Outliers.** While examining projected authorizations, certain months appeared to be inconsistent with the remainder of the observations. These inconsistent months were identified as outliers as previously described in Chapter 3. Outliers were looked at in two different ways. A matter of interest was identifying how many outliers occurred and if they affected the target month. Because of the emphasis placed on the end of the fiscal year by the current smoothing method, it was also of interest to know how many outliers were identified in September. As shown in Table 6-2, only three MOS per month were found in grade E5 which affected the target month, and two out of the three were balanced. There was an average of 13 MOS having outliers occurring in the month of September, of which eight MOS were balanced.

Table 6-2. Impact of Outliers on Number of Balanced MOS, Grade E5

Outliers	Avg no of balanced MOS	Percent balanced MOS	Avg no of observations
Affecting target	2	67	3
Not affecting target	10	59	17
Other	126	51	245
Overall	138	52	265
Occurring in September	8	62	13
Other	130	52	252
Overall	138	52	265

(3) **Steps.** Another pattern emerged while examing projected authorizations. There were noticeable sharp increases and decreases in authorizations and then an immediate stable period. These patterns are referred to as steps which were previously defined in Chapter 3. Table 6-3 shows how ascending and descending steps, occuring with the first fiscal year of the 84-month projections, impacted on the number of balanced MOS.

Table 6-3. Impact of Steps on the Number of Balanced MOS

Steps	Avg no of balanced MOS	Percent balanced MOS	Avg no of observations
Ascending	20	54	37
Descending	30	60	50
Beyond first FY	73	57	127
Other	15	29	51
Overall	138	52	265

(4) **Seasonality.** Since the end of the fiscal year was used to adjust the target in the current smoothing method, a seasonable variation was expected in the month of September. Several statistical measures were used to identify seasonality within a series. A detailed description of these statistical measures is given in Appendix G. Table 6-4 shows that only an average of 13 MOS per month experience the most indication of seasonality, of which 69 percent were balanced.

Table 6-4. Impact of Seasonality on the Number of Balanced MOS, Grade E5

Seasonality	Avg no of balanced MOS	Percent balanced MOS	Avg no of observations
Most indication of	9	69	13
Other	129	51	252
Overall	138	52	265

(5) **Ascending/Descending Patterns.** Some projected authorizations showed a steadily increasing or decreasing pattern. The slopes of the first two fiscal years were examined. Four distinct categories--ascending/ascending, descending/descending, ascending/descending, and descending/ascending--were identified as patterns. Table 6-5 shows that an average of 58 MOS were found with an ascending/ascending pattern, of which 52 percent were balanced.

Table 6-5. Impact of Ascending/Descending Patterns of Number of Balanced MOS, Grade E5

Ascending/descending patterns	Avg no of balanced MOS	Percent balanced MOS	Avg no of observations
Ascending/ascending	30	52	58
Descending/descending	35	57	16
Mixed slope	73	50	146
Overall	138	52	265

(6) **Turbulence.** To measure the turbulence (dispersion) in projected authorizations the coefficient of variation* (CV) for each series was computed over all 84 months of authorizations. Low turbulence is defined as the projected authorizations having a coefficient of variation less than .1, and high turbulence would be greater than .1. Table 6-6 shows that of those MOS identified as having high turbulence, only 36 percent are considered balanced MOS.

Table 6-6. Impact of Turbulence on the Number of Balanced MOS, Grade E5

Turbulence	Avg no of balanced MOS	Percent balanced MOS	Avg no of observations
Coefficient of variation $\leqq$ .1 (low)	116	56	204
Coefficient of variation > .1 (high)	22	36	61
Overall	138	52	265

*See Glossary for the definition of coefficient of variation.

(7) **Turbulence Combined with Ascending/Descending Patterns.** The next pattern examined turbulence with ascending and descending patterns. The slopes and coefficient of variation were calculated for the first and second fiscal years of the projected authorization. Those experiencing a coefficient of variation greater than .1 were combined with different sloping patterns creating three distinct categories--ascending/ascending, descending/descending, and mixed slope--which could have either ascending/descending or descending/ascending patterns. As shown in Table 6-7, an average of 11 MOS per month were found to have high turbulence with ascending/ascending patterns, of which 36 percent were balanced.

Table 6-7. Impact of Turbulence with Ascending/Descending Patterns on the Number of Balanced MOS, Grade E5

Turbulence	Avg no of balanced MOS	Percent balanced MOS	Avg no of observations
High turbulence:			
Ascending/ascending	4	36	11
Descending/descending	4	44	9
Mixed slope	4	36	11
Low turbulence:			
Ascending/ascending	26	55	47
Descending/descending	31	60	52
Mixed slope	69	51	135
Overall	138	52 %	265

(8) **Cross-UAD Patterns.** Three patterns--turbulence, slope, and percent error--were computed across the updated authorization documents (UAD). Within turbulence, authorizations were screened for low and high turbulence. Three types of slopes--descending, level, and ascending--as well as three categories of percent error were examined. Percent error considers the difference between the projected authorization and the actual authorization 2 months later. Subcategories are defined to show bands within and outside of 5 percent error. Table 6-8 portrays the number of balanced MOS in each subcategory of cross-UAD patterns. As shown, approximately 90 percent of the MOS have a percent error across authorization documents of less than 5 percent. Note that the average number of MOS across UAD is 128 and not 138 as in the other patterns previously described. The reason for this is that the cross-UAD analysis looks at 2 months ahead. Not all of this data was available at the time of the study, so only 10 months of data were considered.

Table 6-8. Impact of Patterns Across UAD on the Number of Balanced MOS, Grade E5

Cross-UAD	Avg no of balanced MOS	Percent balanced MOS	Avg no of observations
Turbulence:			
Low	125	51	245
High	3	15	20
Overall	128	48	265
Slope:			
Descending	26	51	51
Level	79	49	162
Ascending	23	44	52
Overall	128	48	265
Percent error:			
> 5 (increasing auth)	2	15	13
≤ 5	124	51	241
< 5 (decreasing auth)	2	18	11
Overall	128	48	265

6-4. RESPONSE TO EEA 2. Some of the authorization patterns examined showed differences between operating strength and targets evaluated based on the percentage of fill. The authorization size showed that the smaller the size of the MOS, the smaller the percentage of balance MOS occurred. Highly turbulent MOS within an authorization document and updating the new authorization documents also showed a low percentage of balanced MOS.

CHAPTER 7

EEA 3: ANALYSIS AND RESULTS

7-1. INTRODUCTION. The purpose of this chapter is to describe analyses and present results which address EEA 3: what is the most effective method of generating targets for each pattern?

7-2. METHODOLOGY. Each of the statistical smoothing techniques was evaluated with respect to the different patterns described in the previous chapter. Evaluation of the different smoothing techniques was based on simulation of the E5/E6 promotion system and computation of fill with respect to the different patterns. It was initially thought that after identifying a certain pattern a distinct smoothing technique would stand out as the best.

7-3. RESULTS

a. Format of Presentation

(1) Tabular results for each of the different patterns identified in the previous chapter are in the form of percentages of balanced MOS for grade E5 computed over the 12 months of analysis (Tables 7-1 through 7-8). Results for grade E6 are presented in Appendix H. All tables show the "historical" and "current" target generation processes used as baselines as well as the other processes which exhibited the highest percentage of balanced MOS. The "historical" process was a reproduction of the targets actually generated during the 12 months of analysis which was based on a double exponential smoothing technique which was later changed to a five-point weighted average. The "current" process is a recomputation of targets throughout the complete 12 months of analysis based on the five-point weighted average. The other processes are the Tukey-Riffenberg, Winters-Holt, removal of outliers, ramp, Tukey plus outlier method, Authorizations (stage 2), and Authorizations (stage 6). As discussed in Chapter 3, Authorizations (stage 2) and Authorizations (stage 6) are target generation processes which do not involve smoothing. These processes are shown in the tables with the statistical smoothing techniques as a point of reference.

(2) Any differences between the percentage of MOS in the categories of fill with this chapter and the previous one are caused by rounding errors due to the small number of observations associated with some of the different patterns.

Table 7-1. Effects of Authorization Size, Percentage of MOS in Categories of Fill (8702-8801), Grade E5

Mean authorization ≤ 20
(23 MOS/month)

Target process	Critically under	Moderately under	Balanced	Moderately over	Critically over	Total
Historical	8	17	21	14	40	100
Current	8	14	22	15	41	100
Auth (Stage 6)	17	11	17	17	39	100
Auth (Stage 2)	8	13	26	14	39	100

20 < Mean authorization ≤ 50
(40 MOS/month)

Historical	6	15	34	27	18	100
Current	6	10	35	30	19	100
Auth (Stage 6)	6	8	37	30	19	100
Auth (Stage 2)	7	9	38	29	17	100

50 < Mean authorization ≤ 100
(52 MOS/month)

Target process	Critically under	Moderately under	Balanced	Moderately over	Critically over	Total
Historical	5	22	45	14	14	100
Current	5	21	47	14	13	100
Outlier (moving avg)	6	20	49	12	13	100
Auth (Stage 2)	10	12	53	14	12	100

100 < Mean authorization
(150 MOS/month)

Historical	2	26	58	11	4	100
Current	2	22	63	9	4	100
Ramp	2	20	64	10	4	100
Auth (Stage 2)	4	11	71	10	4	100

Table 7-2. Identification of Outliers, Percentage of MOS in Categories of Fill (8702 - 8801), Grade E5

Affecting the target month
(3 MOS/month)

Target process	Critically under	Moderately under	Balanced	Moderately over	Critically over	Total
Historical	0	9	51	26	14	100
Current	0	6	57	23	14	100
Auth (Stage 2)	0	6	57	26	11	100
Tukey	0	9	60	20	11	100

Outliers in September
(13 MOS/month)

Target process	Critically under	Moderately under	Balanced	Moderately over	Critically over	Total
Historical	2	13	53	15	17	100
Current	0	15	59	8	17	100
Tukey	0	14	61	9	17	100
Auth (Stage 2)	0	7	65	10	17	100

Table 7-3. Identification of Steps, Percentage of MOS in Categories of Fill (8702-8801), Grade E5

Ascending steps
(37 MOS/month)

Target process	Critically under	Moderately under	Balanced	Moderately over	Critically over	Total
Historical	1	10	55	19	16	100
Current	1	17	54	15	14	100
Ramp	1	12	59	15	13	100
Outlier (MA)	1	13	59	14	14	100
Auth (Stage 2)	0	4	67	14	14	100

Descending steps
(50 MOS/month)

Target process	Critically under	Moderately under	Balanced	Moderately over	Critically over	Total
Historical	1	37	46	7	8	100
Current	0	22	59	10	9	100
Tukey	1	20	61	10	9	100
Auth (Stage 2)	0	10	69	12	9	100

Legend: MA = moving average.

Table 7-4. Identification of Seasonality, Percentage of MOS in Categories of Fill (8702 - 8801), Grade E5

(13 MOS/month)

Target process	Critically under	Moderately under	Balanced	Moderately over	Critically over	Total
Historical	0	16	68	8	8	100
Current	0	14	68	11	7	100
Tukey	0	8	76	9	7	100
Auth (Stage 2)	0	2	77	14	8	100

Table 7-5. Effects of Authorization Slopes, Percentage of MOS in Categories of Fill (8702-8801), Grade E5

Ascending/ascending pattern
(58 MOS/month)

Target process	Critically under	Moderately under	Balanced	Moderately over	Critically over	Total
Historical	2	14	49	23	12	100
Current	3	19	51	18	9	100
Ramp	3	18	52	18	9	100
Tukey	2	20	52	17	9	100
Auth (Stage 2)	5	10	60	15	10	100

Descending/descending pattern
(61 MOS/month)

Target process	Critically under	Moderately under	Balanced	Moderately over	Critically over	Total
Historical	4	37	48	5	6	100
Current	3	25	58	7	8	100
Tukey	3	23	60	6	8	100
Auth (Stage 6)	3	23	59	7	8	100
Auth (Stage 2)	6	12	70	8	7	100

Mixed slopes
(146 MOS/month)

Target process	Critically under	Moderately under	Balanced	Moderately over	Critically over	Total
Historical	3	20	49	15	13	100
Current	5	17	50	15	13	100
Ramp	5	16	51	15	13	100
Outlier (MA)	4	16	52	15	13	100
Auth (Stage 2)	9	11	52	16	12	100

Table 7-6. Effects of Turbulence Across Authorization Documents
Percentage of MOS in Categories of Fill (8702-8801),
Grade E5

Low turbulence
(204 MOS/month)

Target process	Critically under	Moderately under	Balanced	Moderately over	Critically over	Total
Historical	3	28	46	14	9	100
Current	3	24	51	13	9	100
Ramp	4	22	52	13	9	100
Auth (Stage 6)	3	23	52	13	9	100
Auth (Stage 2)	6	15	56	14	9	100

High turbulence
(204 MOS/month)

Target process	Critically under	Moderately under	Balanced	Moderately over	Critically over	Total
Current	9	10	16	26	39	100
Historical	10	12	15	24	39	100
Ramp	11	9	20	25	36	100
Auth (Stage 2)	13	5	21	24	37	100
Auth (Stage 6)	10	7	22	24	38	100

Table 7-7. Effect of Slope Across Authorization Documents Percentage of MOS in Categories of Fill (8702-8801), Grade E5

Descending pattern
(51 MOS/month)

Target process	Critically under	Moderately under	Balanced	Moderately over	Critically over	Total
Historical	3	18	47	19	13	100
Current	3	14	51	19	13	100
Tukey	4	14	51	18	13	100
Outlier (MA)	4	15	51	17	13	100
Outlier (Str-line)	4	15	51	17	13	100
Auth (Stage 6)	4	15	51	17	13	100
Auth (Stage 2)	6	10	54	18	13	100

Level pattern
(162 MOS/month)

Target process	Critically under	Moderately under	Balanced	Moderately over	Critically over	Total
Historical	3	24	44	15	14	100
Current	3	20	49	14	14	100
Ramp	3	18	51	14	14	100
Outlier (MA)	3	18	51	14	14	100
Outlier (Str-line)	3	18	51	14	14	100
Auth (Stage 6)	3	18	51	14	14	100
Auth (Stage 2)	6	11	54	16	13	100

Ascending pattern
(52 MOS/month)

Target process	Critically under	Moderately under	Balanced	Moderately over	Critically over	Total
Historical	6	41	40	10	3	100
Current	6	40	44	7	3	100
Ramp	6	38	47	8	1	100
Auth (Stage 2)	11	27	53	6	3	100

Table 7-8. Percent Change Across Authorization Documents Percentage of MOS in Categories of Fill (8702-8801), Grade E5

> 5 percent (increasing authorization)
(43 MOS/month)

Target process	Critically under	Moderately under	Balanced	Moderately over	Critically over	Total
Historical	6	41	40	10	3	100
Current	6	40	44	7	3	100
Ramp	6	38	47	8	2	100
Auth (Stage 2)	11	27	53	6	3	100

> 5 percent (decreasing authorization)
(42 MOS/month)

Historical	3	18	47	19	13	100
Outlier (Str - line)	4	15	50	18	13	100
Current	4	14	51	19	12	100
Auth (Stage 2)	6	10	54	18	12	100

≤ 5 percent change
(241 MOS/month)

Historical	3	26	46	14	11	100
Current	3	22	52	13	11	100
Outlier (Str - line)	3	21	53	13	11	100
Auth (Stage 6)	3	21	53	13	11	100
Outlier (Moving avg)	3	21	53	13	11	100
Ramp	3	20	53	13	10	100
Auth (Stage 2)	6	13	58	13	10	100

b. **Interpretation.** Table 7-9 shows the percentage of MOS in the different categories of fill for all the smoothing techniques as well as the two forms of authorizations. This is an overall comparison and is representative of all the different patterns. As shown, the percentage of balanced MOS increased from 48 percent to 52 percent for the "historical" and "current" processes, respectively. The process based on Winters-Holt smoothing was the only process that was worse than the current smoothing process.

Table 7-9. Comparison of Smoothing Techniques in Target Generation, Percentage of MOS in Categories of Fill (8702-8801), Grade E5

Target process	Category of fill					
	Critically under	Moderately under	Balanced	Moderately over	Critically over	Total
Historical	4	23	48	14	11	100
Winters	4	21	48	27	11	100
Current	4	20	52	14	11	100
Tukey & outlier	4	19	53	14	11	100
Outlier (Str - line)	4	19	53	14	11	100
Auth (Stage 6)	4	19	53	13	11	100
Tukey	4	19	53	14	11	100
Outlier (MA)	4	18	53	14	11	100
Ramp	4	18	53	14	11	100
Auth (Stage 2)	7	11	58	14	11	100

7-4. RESPONSE TO EEA 3. The largest difference between target generatoin processes was between the "historical" and the "current" smoothing techniques, in which there was an increase from 48 percent to 52 percent balanced MOS, respectively. All the other statistical smoothing techniques were indistinguishable when applied to the different patterns.

CHAPTER 8

EEA 4: ANALYSIS AND RESULTS

8-1. INTRODUCTION. The purpose of this chapter is to describe analyses and present results which address EEA 4: if smoothing of the authorizations is appropriate, when in the target generation process should it be performed?

8-2. METHODOLOGY

a. Figure 8-1 is a reproduction of paths 1 and 3 of Figure 1-1. Path 1 is the current smoothing process where targets are generated in six computational stages. In the current process, stage 2 authorizations are the ones that are smoothed. Path 3 refers to the smoothing of all stage 6 authorizations, with subsequent readjustment to meet grade limitations.

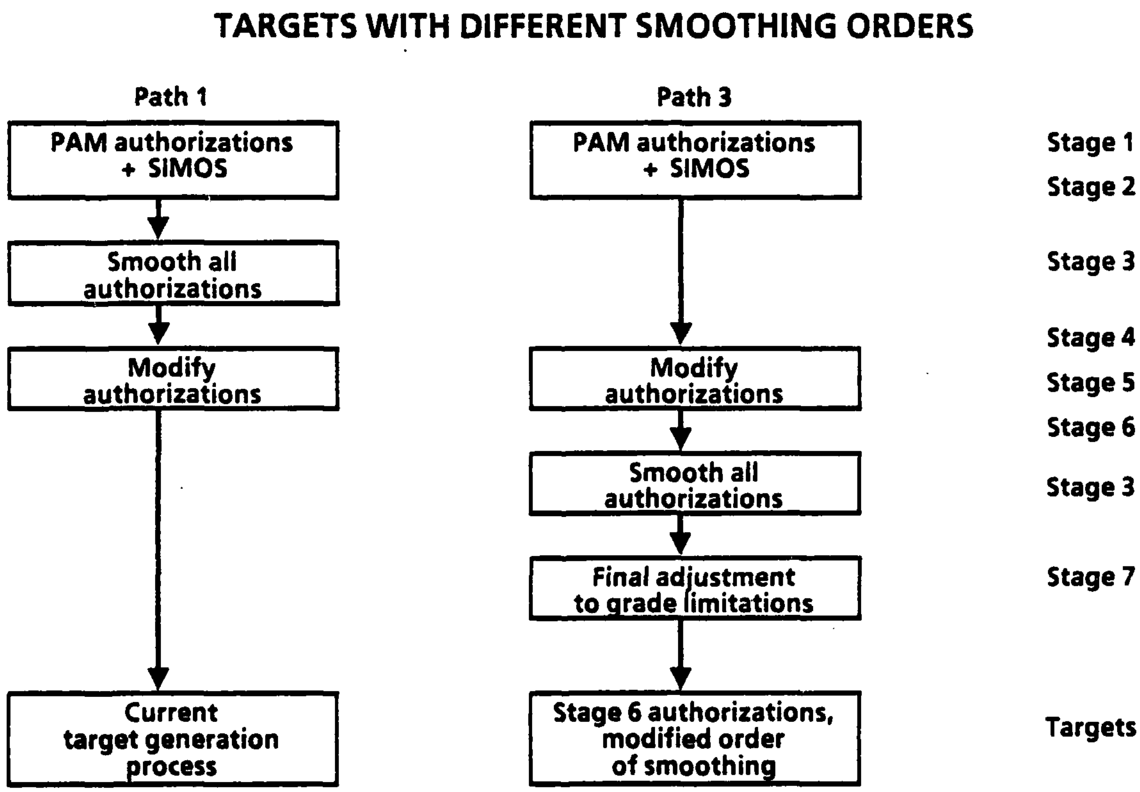


Figure 8-1. Methodology (EEA 4)

b. Comparisons of current and modified order of smoothing were based on four different statistical smoothing techniques: (1) the current five-point weighted moving average smoothing technique, (2) the Tukey-Riffenberg technique, (3) the straightline smoothing of stage 6 authorizations identified as outliers, and (4) the smoothing of outliers using a five-point moving average.

8-3. RESULTS

a. Format of Presentation. Percentage of MOS in categories of fill and average numbers of soldiers understrength or overstrength per month, based on the 12 months of analysis, are presented in Tables 8-1 through 8-4. All measures of fill (numbers, percentages, strength of MOS in categories of fill, understrength and overstrength, averaged over the 12 months of analysis) are in Appendix I, Tables I-9 through I-16. In each of these tables, current and modified orders of smoothing are presented in pairs, current order first, followed by modified order; each pair is distinguished by a different statistical smoothing technique.

b. Interpretation

(1) Modified order of smoothing results in increases of percentage of balanced MOS by 1 to 2 percent in grades E5 and E6 using the Tukey-Riffenberg smoothing technique and straightline removal of outliers (Tables 8-1 and 8-2). Straightline removal of outliers applied to stage 6 authorizations, rather than to stage 2 authorizations, also increases strength of balanced MOS from 68,468 to 72,748 soldiers, grade E5, and from 59,813 to 60,208 soldiers, grade E6 (Tables I-13 and I-14 of Appendix I). Applying the Tukey-Riffenberg smoothing technique to stage 6 authorizations, rather than to stage 2 authorizations, increases strength of balanced MOS from 69,259 to 70,199, grade E5, and from 59,905 to 60,005, grade E6.

(2) Plots in Figures 8-2, grade E5, and 8-3, grade E6, show that the improvement over the historical method, in percentages of balanced MOS, is consistent for each of the 12 months of analysis, comparing straightline removal of outliers in stage 6 authorizations with straightline removal of outliers in stage 2 authorizations.

(3) An average of only 1.6 outliers occurs per month in grade E5 and 0.5 per month in grade E6 for stage 6 authorizations. (For stage 2 authorizations, an average of only 3.0 such outliers occurs per month in grade E5 and 1.3 in grade E6.) To demonstrate that targets created from straightline removal of outliers in stage 6 authorizations are very similar to targets which are simply stage 6 authorizations, percentages of balanced MOS for these two types of targets are plotted by month in Figures 8-4, grade E5, and 8-5, grade E6. When stage 6 authorizations are smoothed for outliers, these plots show improved percentages of balanced MOS.

Table 8-1. Smoothing Order Comparisons, Percentage of MOS in Categories of Fill (8702-8801), Grade E5

Target process	Category of fill					
	Critically under	Moderately under	Balanced	Moderately over	Critically over	Total
AUTH (Stage 2), C	4	20	52	14	11	100
AUTH (Stage 6), C	4	20	52	14	11	100
AUTH (Stage 2), T	4	19	53	14	11	100
AUTH (Stage 6), T	4	19	54	13	11	100
AUTH (Stage 2) - outliers (SL)	4	19	53	14	11	100
AUTH (Stage 6) - outliers (SL)	4	17	55	13	10	100
AUTH (Stage 2) - outliers (MA)	4	18	53	14	11	100
AUTH (Stage 6) - outliers (MA)	4	19	52	14	11	100
AUTH (Stage 6)	4	19	53	13	11	100

C = Current smoothing technique
T = Tukey statistical smoother

Table 8-2. Smoothing Order Comparisons, Percentage of MOS in Categories of Fill (8702-8801), Grade E6

Target process	Category of fill					
	Critically under	Moderately under	Balanced	Moderately over	Critically over	Total
AUTH (Stage 2), C	3	8	54	23	13	100
AUTH (Stage 6), C	3	8	52	22	13	100
AUTH (Stage 2), T	3	7	54	23	13	100
AUTH (Stage 6), T	3	7	55	23	13	100
AUTH (Stage 2) - outliers (SL)	3	7	54	22	14	100
AUTH (Stage 6) - outliers (SL)	3	7	56	21	13	100
AUTH (Stage 2) - outliers (MA)	3	7	54	23	14	100
AUTH (Stage 6) - outliers (MA)	3	7	54	23	14	100
AUTH (Stage 6)	3	7	54	22	14	100

C = Current smoothing technique
T = Tukey statistical smoother

Table 8-3. Smoothing Order Comparisons, Average Strength of MOS in Understrength and Overstrength (8702-8801), Grade E5

Target process \ Average strength	Understrength	Overstrength
AUTH (Stage 2), C	-4,721	2,945
AUTH (Stage 6), C	-4,679	2,684
AUTH (Stage 2), T	-4,664	2.698
AUTH (Stage 6), T	-4,621	2,646
AUTH (Stage 2) – outliers (SL)	-4,700	2,714
AUTH (Stage 6) – outliers (SL)	-4,662	2,618
AUTH (Stage 2) – outliers (MA)	-4,695	2,710
AUTH (Stage 6) – outliers (MA)	-4,664	2,705
AUTH (Stage 6)	-4,703	2,706

C = Current smoothing technique
T = Tukey statistical smoother

Table 8-4. Smoothing Order Comparisons, Average Strenghth of MOS in Understrength and Overstrength (8702 - 8801) Grade E6

Target process \ Average strength	Understrength	Overstrength
AUTH (Stage 2), C	-1,554	2,351
AUTH (Stage 6), C	-1,555	2,326
AUTH (Stage 2), T	-1,535	2.338
AUTH (Stage 6), T	-1,520	2,314
AUTH (Stage 2) – outliers (SL)	-1,555	2,367
AUTH (Stage 6) – outliers (SL)	-1,556	2,340
AUTH (Stage 2) – outliers (MA)	-1,552	2,365
AUTH (Stage 6) – outliers (MA)	-1,561	2,376
AUTH (Stage 6)	-1,564	2,359

C = Current smoothing technique
T = Tukey statistical smoother

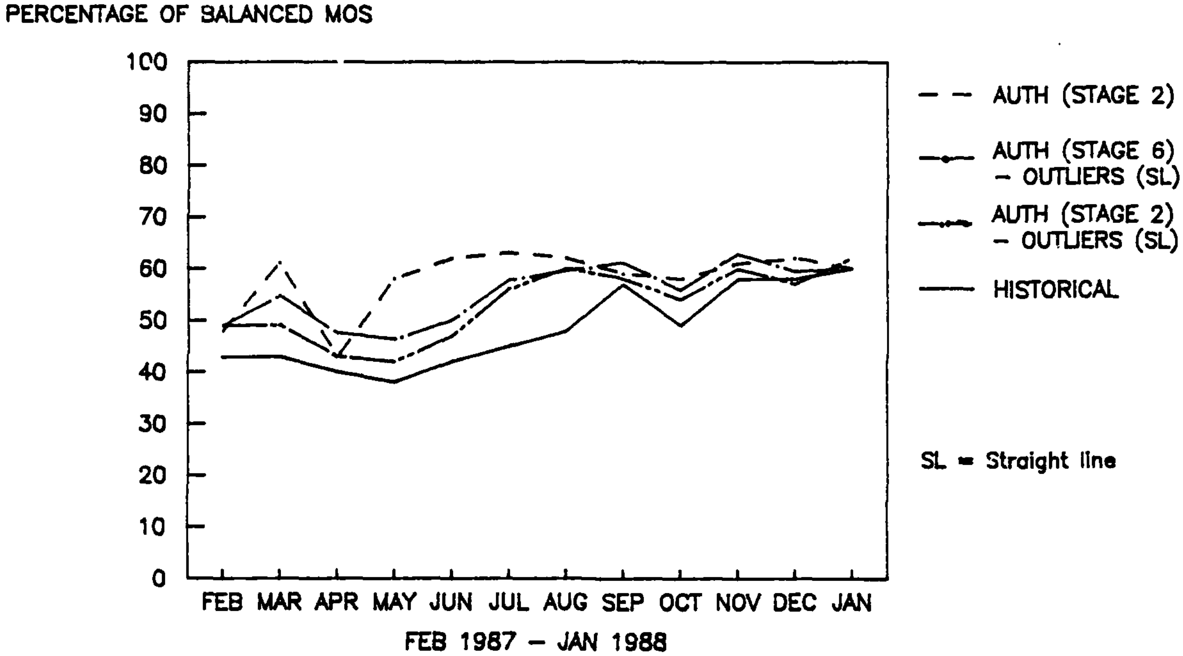


Figure 8-2. Comparing Smoothing Order with the Historical Method, Grade E5

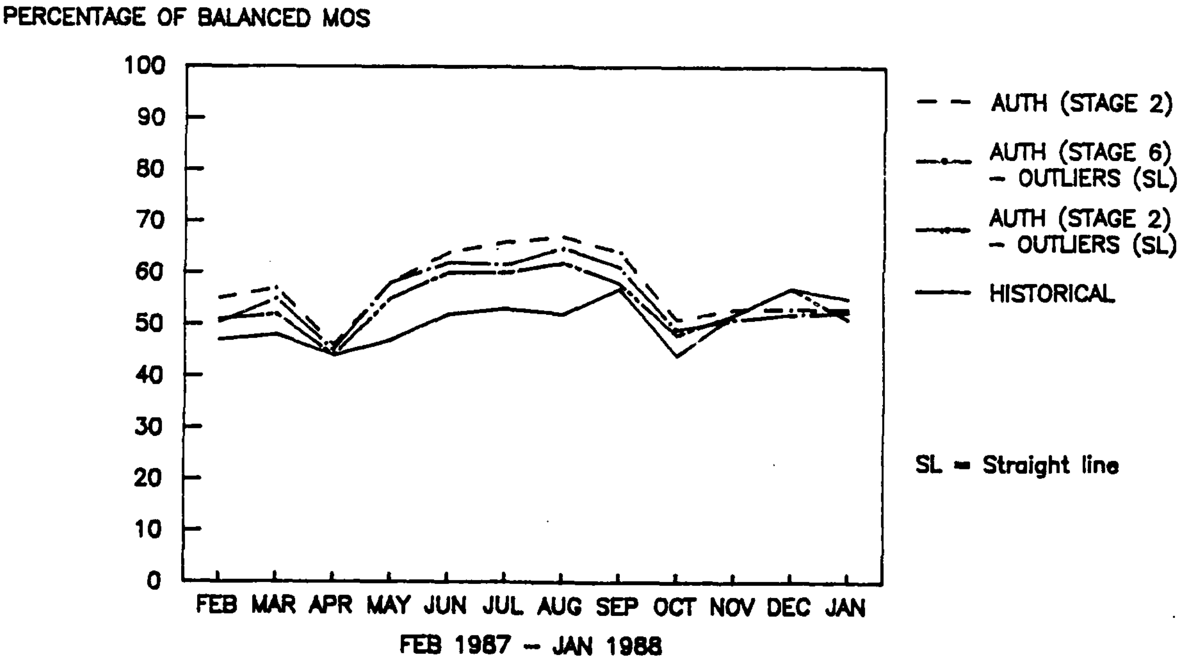


Figure 8-3. Comparing Smoothing Order with the Historical Method, Grade E-6

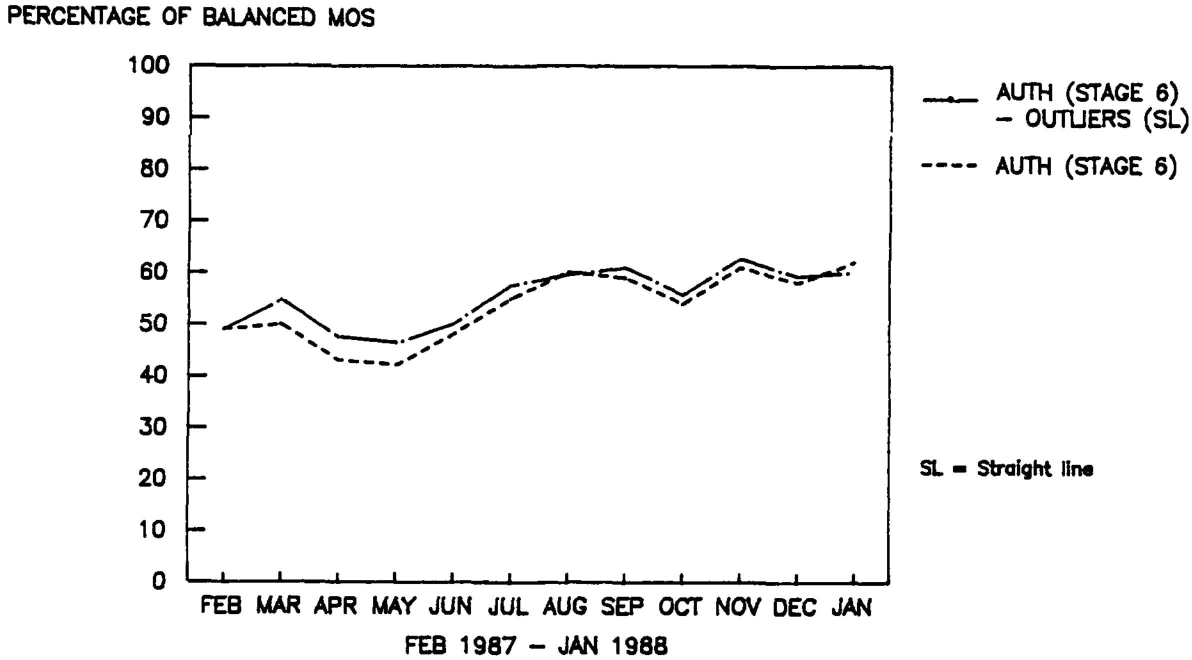


Figure 8-4. Comparing Smoothing Order in the Target Generation Process, Grade E5

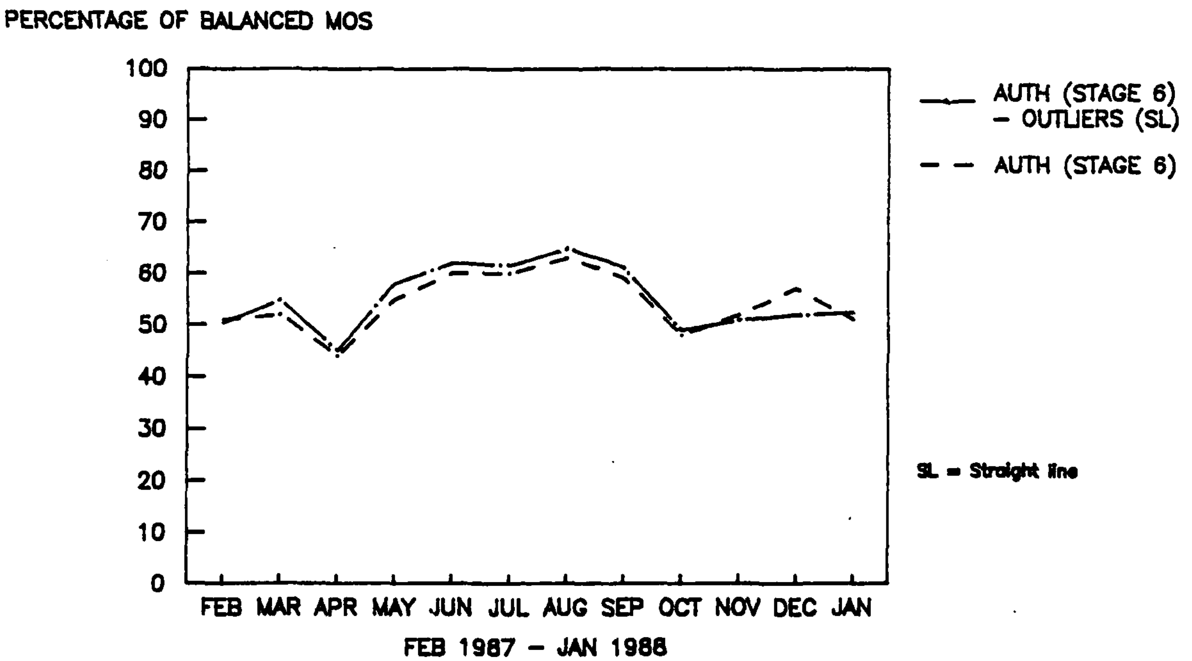


Figure 8-5. Comparing Smoothing Order in the Target Generation Process, Grade E6

(4) The straightline removal of outliers in stage 6 authorizations, rather than in stage 2 authorizations, also results in the greatest reduction of percentages of MOS over the four categories of underfill and overfill, totaling 4 percent in grade E5 and 2 percent in grade E6 (Tables 8-1 and 8-2).

(5) Improvement due to smoothing stage 6 authorizations, rather than stage 2 authorizations, also is demonstrated by reduced numbers of shortages and overages in grade E5 and by reduced numbers of overages in grade E6 for all four comparisons. The greatest reduction in both under- and overstrength occurs for Tukey smoothing of stage 6 authorizations. Understrength is reduced by 43 soldiers for grade E5, and by 15 soldiers for grade E6; reduction in overstrength is by 52 soldiers for grade E5, and by 24 soldiers for grade E6 when applying the modified order of smoothing.

(6) Smoothing of outliers in the stage 6 authorizations using the five-point moving average technique is associated with worsened results with respect to: (1) percentage of balanced MOS (reduced by 1 or 2 percent, grades E5 and E6), (2) average understrength (increased by 11 soldiers, grade E6, and (3) average overstrength (increased by 11 soldiers, grade E6). Increase of average understrength per month by one soldier also occurs in grade E6 for the straightline removal of outliers, modified smoothing order.

8-4. RESPONSE TO EEA 4

a. Smoothing of authorizations should be applied to stage 6 authorizations rather than to stage 2 authorizations, when smoothing is by straightline removal of outliers or by the Tukey-Riffenberg statistical technique.

(1) The greatest improvement with respect to distribution of MOS in categories of fill occurs when straightline smoothing of outliers is applied to stage 6, rather than to stage 2 authorizations (percentage of balanced MOS increased by 2 percent, grade E5, and by 1 percent, grade E6; percentages of MOS over the four imbalance categories decreased by a total of 4 percent, grade E5, and 2 percent, grade E6).

(2) Application of the Tukey statistical smoothing technique to stage 6 authorizations, rather than to stage 2 authorizations, results in the greatest reduction of average numbers of soldiers understrength (43 soldiers, E5, and 15 soldiers, E6) and also in the greatest reduction of average numbers of soldiers overstrength (52 soldiers, E5, and 24 soldiers, E6). Reduction in understrength (both grades E5 and E6) and reduction in overstrength (grade E6) occurred for all comparisons, replacing current order of smoothing by the modified order.

b. Smoothing stage 6 authorizations identified as outliers can be viewed as a minor modification of the stage 6 authorization. Considering only those stage 6 authorizations (projections centered about the third projection) that affect the E5/E6 promotion determination, an average of only 1.6 such outliers occur every month in grade E5, and 0.5 in grade E6.

CHAPTER 9

EEA 6: ANALYSIS AND RESULTS

9-1. INTRODUCTION. The purpose of this chapter is to describe analyses and present results which address EEA 6: what are the effects of incorporating consideration of the availability of the soldiers eligible for promotion, the existence of overfill, the protection of space imbalanced MOS (SIMOS), and other constraints on fill, for each MOS at grades E5 and E6, over time?

9-2. METHODOLOGY. Targets provided to the E5/E6 promotion system are used to determine numbers needed for promotion, but these numbers needed are constrained to sum to promotion ceilings derived monthly from budgetary requirements. Consideration of the availability of soldiers eligible for promotion, the existence of overfill, and the protection of SIMOS are related to this constraining process.

9-3. RESULTS

a. The automatic component of the current analytical process of constraining numbers needed for promotion to promotion ceilings was reproduced in the CAA simulation of the E5/E6 promotion system, as described in Chapter 4. Availability of soldiers eligible for promotion and the existence of overfill were incorporated into this process. Differences between results based on the automatic reduction and the current process which combines automatic reduction with expert judgment were also presented in Chapter 4. Results were not substantially different. Nor did completely removing constraints on numbers needed for promotion substantially improve percentages of balanced MOS, as was shown in Tables 4-1 and 4-2. This was taken as evidence that the current constraining process is favorable to maintaining balanced fill.

b. Two additional types of analyses were developed in this chapter, in response to EEA 6: protection analyses and selective smoothing analyses.

(1) Protection Analyses. Protection refers to the process of constraining numbers needed for promotion to promotion ceilings (the creation of the "promotion determination"). Results of three analyses on protection are reported in Tables 9-1 through 9-4 (percentages of MOS in categories of fill and average understrength and overstrength per month for grades E5 and E6. Complete sets of tables (numbers, percentages, strength, and understrength/overstrength) are in Appendix I, Tables I-17 through I-24.

Table 9-1. Protecting Selected Authorizations, Percentage of MOS in Catgories of Fill (8702-8801), Grade E5

Target process	Category of fill					
	Critically under	Moderately under	Balanced	Moderately over	Critically over	Total
TUKEY	4	19	53	14	11	100
T + SIMOS	4	17	56	13	11	100
A2	7	11	58	14	11	100
A2 + PS	7	10	58	15	11	100
A2 + PS + PD	7	10	58	15	11	100

TUKEY: Tukey-Riffenberg.

T + SIMOS: Tukey + protect authorizations inflated for space imbalance and other undocumented requirements.

A2: Authorizations, stage 2.

A2+PS: Authorizations, stage 2 + protect authorizations < 50.

A2+PS+PD: Authorizations, stage 2 + protect small authorizations + protect increasing (decreasing) authorizations when numbers needed are scaled downward (upward).

Table 9-2. Protecting Selected Authorizations, Percentage of MOS in Catgories of Fill (8702-8801), Grade E6

Target process	Category of fill					
	Critically under	Moderately under	Balanced	Moderately over	Critically over	Total
TUKEY	3	7	54	23	13	100
T + SIMOS	3	7	54	22	13	100
A2	3	5	57	22	13	100
A2 + PS	3	4	57	22	14	100
A2 + PS + PD	3	4	57	23	14	100

TUKEY: Tukey-Riffenberg.

T + SIMOS: Tukey + protect authorizations inflated for space imbalance and other undocumented requirements.

A2: Authorizations, stage 2.

A2+PS: Authorizations, stage 2 + protect authorizations < 50.

A2+PS+PD: Authorizations, stage 2 + protect small authorizations + protect increasing (decreasing) authorizations when numbers needed are scaled downward (upward).

Table 9-3. Protecting Selected Authorizations, Average Strength of MOS in Understrength and Overstrength (8702-8801), Grade E5

Target process	Understrength	Overstrength
TUKEY	-4,664	2,698
T + SIMOS	-4,642	2,640
A2	-5,141	2,796
A2 + PS	-5,148	2,807
A2 + PS + PD	-4,711	2,876

TUKEY: Tukey-Riffenberg.

T + SIMOS: Tukey + protect authorizations inflated for space imbalance and other undocumented requirements.

A2: Authorizations, stage 2.

A2+PS: Authorizations, stage 2 + protect authorizations < 50.

A2+PS+PD: Authorizations, stage 2 + protect small authorizations + protect increasing (decreasing) authorizations when numbers needed are scaled downward (upward).

Table 9-4. Protecting Selected Authorizations, Average Strength of MOS in Understrength and Overstrength (8702-8801), Grade E6

Target process	Understrength	Overstrength
TUKEY	-1,535	2,338
T + SIMOS	-1,473	2,339
A2	-1,522	2,329
A2 + PS	-1,532	2,334
A2 + PS + PD	-1,170	2,490

TUKEY: Tukey-Riffenberg.

T + SIMOS: Tukey + protect authorizations inflated for space imbalance and other undocumented requirements.

A2: Authorizations, stage 2.

A2+PS: Authorizations, stage 2 + protect authorizations < 50.

A2+PS+PD: Authorizations, stage 2 + protect small authorizations + protect increasing (decreasing) authorizations when numbers needed are scaled downward (upward).

(a) Protecting Critical MOS. Authorizations selectively inflated for SIMOS and other undocumented policy requirements were defined as "critical" and were not allowed to be reduced in the constraining process. This protection was applied to targets created by the current six-stage target generation process using the Tukey-Riffenberg statistical smoothing technique. Percentage of balanced MOS increased from 53.3 percent to 55.7 percent, grade E5 and from 54.3 percent to 54.4 percent, grade E6, based on protection. However, these percentages were still not as high as percentages of balanced MOS reported for the stage 2 authorization (58 percent, grade E5, and 57 percent, grade E6).

(b) Protecting Small MOS. Stage 2 authorizations less than or equal to 50 were not allowed to be changed in the constraining process. Neither improved percentages of balanced MOS nor reduced understrength and overstrength, however, resulted from this protection. Dominant existence of small MOS and differences between the promotion determination and actual numbers promoted in the E5/E6 promotion system evidently invalidate efficacy of the protection process for small MOS.

(c) Protecting Ascending (or Descending) Authorizations. Authorization projections which are consistently ascending (or consistently descending) in projections of the first two fiscal years are protected when numbers are constrained downward (or upward). Small MOS are also protected in the analyses reported. This type of protection results in reduction in percentages of balanced MOS by 0.4 percent in grade E5 and by 0.4 percent in grade E6.

(d) Difficulties with Protection. Particularly when large MOS are protected, reduction of numbers needed for promotion to required promotion ceilings may be impossible. For analyses referred to in (a) and (c) above, such reduction was indeed not possible for some months of analysis; to achieve the required reduction, large MOS could only be "partially protected."

(2) Selective Smoothing Analyses. Targets generated through the current six-stage computational process are constrained to grade limitations. Stage 2 authorizations are not constrained to grade limitations. But by being directly input into the E5/E6 promotion system, stage 2 authorizations are constrained to the promotion ceilings imposed on the system; any previous adjustment to grade limitations would be eradicated. Consequently, further work with the stage 2 authorization within the E5/E6 promotion system seemed appropriate, especially since distinctly high percentages of balanced MOS were reported for the stage 2 authorization.

(a) In Tables 9-5 through 9-8 referred to below, results are presented for the stage 2 authorization and two versions in which stage 2 authorizations are selectively smoothed for outliers and step functions. In one version of selective smoothing, stage 2 authorizations identified as outliers or steps are smoothed using the Tukey-Riffenberg statistical smoothing technique. In the second version, smoothing occurs by building ramps. Incorporated into both of these versions of selective smoothing is the protection of small MOS. Tables 9-5 through 9-8 are averages of percentages of MOS in categories of fill and average monthly understrength and overstrength.

Numbers, percentages, and strength of MOS in categories of fill and average monthly understrength and overstrength are in Tables I-25 through I-40 of Appendix I.

Table 9-5. Effects of Selective Smoothing Methods, Percentage of MOS in Categories of Fill (8702-8801), Grade E5

Target process	Category of fill					
	Critically under	Moderately under	Balanced	Moderately over	Critically over	Total
Auth (stage 2)	7	11	58	14	11	100
Auth (stage 2)[a] - steps, outliers (T)	5	10	58	17	11	100
Auth (stage 2)[a] - steps, outliers (R)	5	9	58	17	11	100

[a]Also, protect authorizations ≤50.

T = Tukey statistical smoother, R = construction of ramps.

Table 9-6. Effects of Selective Smoothing Methods, Percentage of MOS in Categories of Fill (8702-8801), Grade E6

Target process	Category of fill					
	Critically under	Moderately under	Balanced	Moderately over	Critically over	Total
Auth (stage 2)	3	5	57	22	13	100
Auth (stage 2)[a] - steps, outliers (T)	2	3	58	23	14	100
Auth (stage 2)[a] - steps, outliers (R)	2	3	58	23	14	100

[a]Also, protect authorizations ≤50.

T = Tukey statistical smoother, R = construction of ramps.

Table 9-7. Effects of Selective Smoothing Methods, Average Strength of MOS in Understrength and Overstrength (8702-8801), Grade E5

Target process	Average number	
	Understrength	Overstrength
Auth (stage 2)	-5,141	2,796
Auth (stage 2)[a] - steps, outliers (T)	-4,127	3,179
Auth (stage 2)[a] - steps, outliers (R)	-4,140	3,166

[a]Also, protect authorizations ≤50.

T = Tukey statistical smoother, R = construction of ramps.

Table 9-8. Effects of Selective Smoothing Methods, Average Strength of MOS in Understrength and Overstrength (8702-8801), Grade E6

Target process	Average number	
	Understrength	Overstrength
Auth (stage 2)	-1,522	2,329
Auth (stage 2)[a] - steps, outliers (T)	1,034	2,571
Auth (stage 2)[a] - steps, outliers (R)	1,042	2,557

[a]Also, protect authorizations ≤50.

T = Tukey statistical smoother, R = construction of ramps.

(b) The effect of both versions of selective smoothing is very similar: both versions shift imbalance from underfill in the direction of overfill, especially in grade E5. Both maintain high percentages of balanced MOS. Of the two versions, Tukey-Riffenberg selective smoothing achieves a slightly greater reduction in average number of shortages per month (1,014 fewer shortages, grade E5, and 488 fewer shortages, grade E6, relative to the current method). The Tukey-Riffenberg version also results in greater average number of overages per month (383 more overages, grade E5, and 242 more overages, grade E6, than the current method).

(c) Because selective smoothing of stage 2 authorizations produced distinct differences in results from the stage 2 authorization (by shifting imbalance from underfill to overfill), results based on the Tukey-Riffenberg version will be presented again in Chapter 10, in response to EEA 5.

9-4. RESPONSE TO EEA 6

a. Considering availability of soldiers eligible for promotion, the existence of overfill and the protection of SIMOS did not lead to improved target methodology. Two types of analyses were performed:

(1) **Stage 2 Authorizations Used as Targets.** Protecting ascending authorizations and small authorizations from reduction during the process of constraining numbers needed for promotion to promotion ceilings worsened percentages of balanced MOS by 0.4, grade E5, and by 0.4, grade E6.

(2) **Statistically Smoothed Authorizations (Tukey-Riffenberg) Used as Targets.** Protecting critical MOS (stage 2 authorizations inflated according to policy requirements) improved percentages of balanced MOS by 2.4 percent, grade E5, and by 0.1 percent, grade E6. These improved percentages were still lower (by 2.4 percent in grade E5 and by 2.8 percent in grade E6) than percentages based on using stage 2 authorizations used directly as targets.

b. Difficulties were associated with the protection process, in that protecting large MOS in some months of analysis prevented the necessary reduction of numbers needed for promotion to required promotion ceilings.

CHAPTER 10

EEA 5: ANALYSIS AND RESULTS

10-1. INTRODUCTION. The purpose of this chapter is to present results which support EEA 5: "How do alternate target generation processes compare with the current process?" In this chapter are selected results from Chapters 5 through 9 associated with target generation processes which either produced distinctly superior results or were of methodological interest. Discussion of results presented in this chapter is formatted in response to EEA 5. This chapter is a review of target generation processes identified as most important to the study.

10-2. METHODOLOGY. The diagram of five different types of target generation processes, represented as five paths in Figure 1-1, is reproduced as Figure 10-1. In this chapter are presented results for four variations of the target generation process represented by the first path; results representing each of the other four paths are also presented. A review of these five different types of target generation processes is as follows:

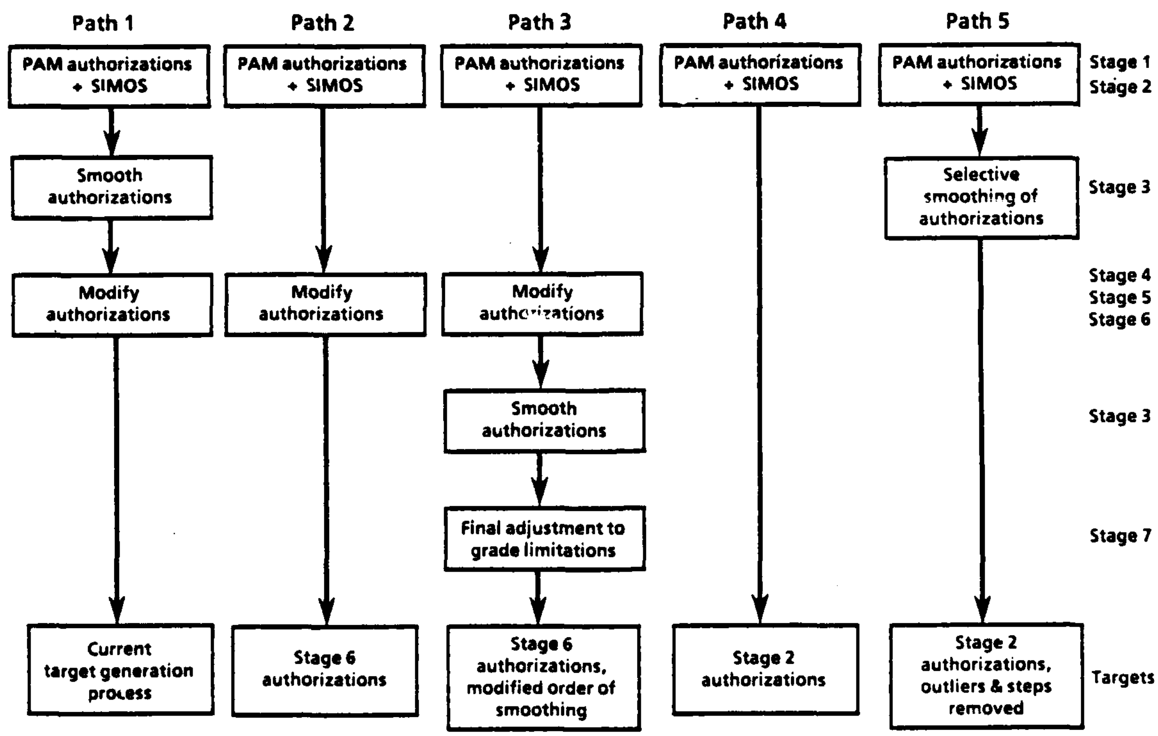


Figure 10-1. Target Generation Processes

a. Current Target Generation Process. The first path is a reproduction of the current six-stage computational process. Variations of this current process refer to the statistical smoothing techniques applied to the stage 2 authorizations. The variations are referred to in the following tables as: (1) "historical," (2) "current," (3) "Tukey," and (4) "Ramp." Reproduction of the historical smoothing technique and the five-point weighted moving average technique (currently implemented) forms baselines for study results. Smoothing by Tukey-Riffenberg and construction of ramps are of methodological interest.

b. Stage 6 Authorizations. Path 2 refers to elimination of smoothing. The "stage 6 authorization" target generation process is a reproduction of the current 6 stage computational process but with smoothing eliminated.

c. Stage 6 Authorizations with Outliers Removed. In path 3, the order of smoothing is modified. In the modified order, smoothing occurs subsequent to inflation of authorizations to total Army strength projections, addition of THS, and constraints to grade limitations. The variation of modified smoothing selected for presentation in this chapter from Chapter 8 (where current and modified order of smoothing was compared) is the straightline smoothing of outliers identified in stage 6 authorizations. In Chapter 8, a slightly superior distribution of percentages of balanced MOS in categories of fill was observed for this process, relative to other processes evaluated. In the following tables this process is referred to as "Auth (stage 6) - outliers."

d. Stage 2 Authorizations. In path 4, the stage 2 authorization is directly used as the target.

e. Stage 2 Authorizations with Outliers and Steps Removed. Path 5 represents the smoothing of stage 2 authorizations (using the Tukey-Riffenberg smoothing technique) identified as steps and outliers. Authorizations less than or equal to 50 are also protected. No subsequent computations on these (selectively) smoothed authorizations are performed. In the following tables this method is referred to as "Auth (stage 2) - steps, outliers."

10-3. RESULTS

a. Format of Presentation. Variations of the five different types of target generation processes on which results in Tables 10-1 through 10-4 are based are:

Historical (double exponential smoothing/five-point weighted moving average)
Current (5 point weighted moving average)
Constructing ramps
Statistical smoothing (Tukey-Riffenberg)
Authorizations (stage 2)
Authorizations (stage 2), smoothing steps and outliers, protecting small authorizations
Authorizations (stage 6)
Authorizations (stage 6), smoothing outliers

These tables contain percentages of MOS in categories of fill, average understrength and overstrength per month, based on the 12 months of analysis. Plots of percentages of balanced MOS, by month, are in Figures 10-2 and 10-3. The complete set of all four measures of fill (numbers, percentages, strength in categories of fill and average understrength and overstrength per month, based on the 12 months of analysis), are in Appendix I, Tables I-25 through I-32. Supplementary results by month are in Appendix F.

Table 10-1. Comparison of Target Generation Processes - Percentage of MOS in Categories of Fill (8702-8801), Grade E5

Target process	Category of fill					
	Critically under	Moderately under	Balanced	Moderately over	Critically over	Total
Historical	4	23	48	14	11	100
Current	4	20	52	14	11	100
Auth (stage 6)	4	19	53	13	11	100
Tukey	4	19	53	14	11	100
Ramp	4	18	54	14	11	100
Auth (stage 6) - outliers	4	17	55	13	10	100
Auth (stage 2)	7	11	58	14	11	100
Auth (stage 2)[a] - steps, outliers	6	9	58	15	11	100

[a]Also, protect small MOS (≤50).

Table 10-2. Comparisons of Target Generation Processes Average Strength of MOS in Understrength and Overstrength (8702-8801), Grade E5

Target process	Average strength	
	Understrength	Overstrength
Auth (stage 2)[a] - steps, outliers	-4,127	3,179
Historical	-4,979	2,945
Auth (stage 2)	-5,141	2,796
Current	-4,721	2,715
Auth (stage 6)	-4,703	2,706
Tukey	-4,664	2,698
Ramp	-4,717	2,687
Auth (stage 6) - outliers	-4,662	2,618

[a]Also, protect small MOS (≤50).

Table 10-3. Comparison of Target Generation Processes - Percentage of MOS in Categories of Fill (8702-8801), Grade E6

Target process	Category of fill					
	Critically under	Moderately under	Balanced	Moderately over	Critically over	Total
Historical	3	9	51	24	14	100
Current	3	8	54	23	13	100
Auth (stage 6)	3	7	54	23	13	100
Tukey	3	7	54	22	13	100
Ramp	3	7	54	23	14	100
Auth (stage 6) - outliers	3	7	56	21	13	100
Auth (stage 2)	3	5	57	22	13	100
Auth (stage 2)[a] - steps, outliers	3	4	57	22	14	100

[a]Also, protect small MOS (≤50).

Table 10-4. Comparison of Target Generation Processes - Average Strength of MOS in Understrength and Overstrength (8702-8801), Grade E6

Target process	Average strength	
	Understrength	Overstrength
Auth (stage 2)[a] - steps, outliers	-1,033	2,570
Historical	-1,591	2,487
Ramp	-1,548	2,363
Auth (stage 6)	-1,564	2,359
Auth (stage 6) - outliers	-1,556	2,340
Current	-1,554	2,351
Tukey	-1,535	2,338
Auth (stage 2)	-1,522	2,329

[a]Also, protect small MOS (≤50).

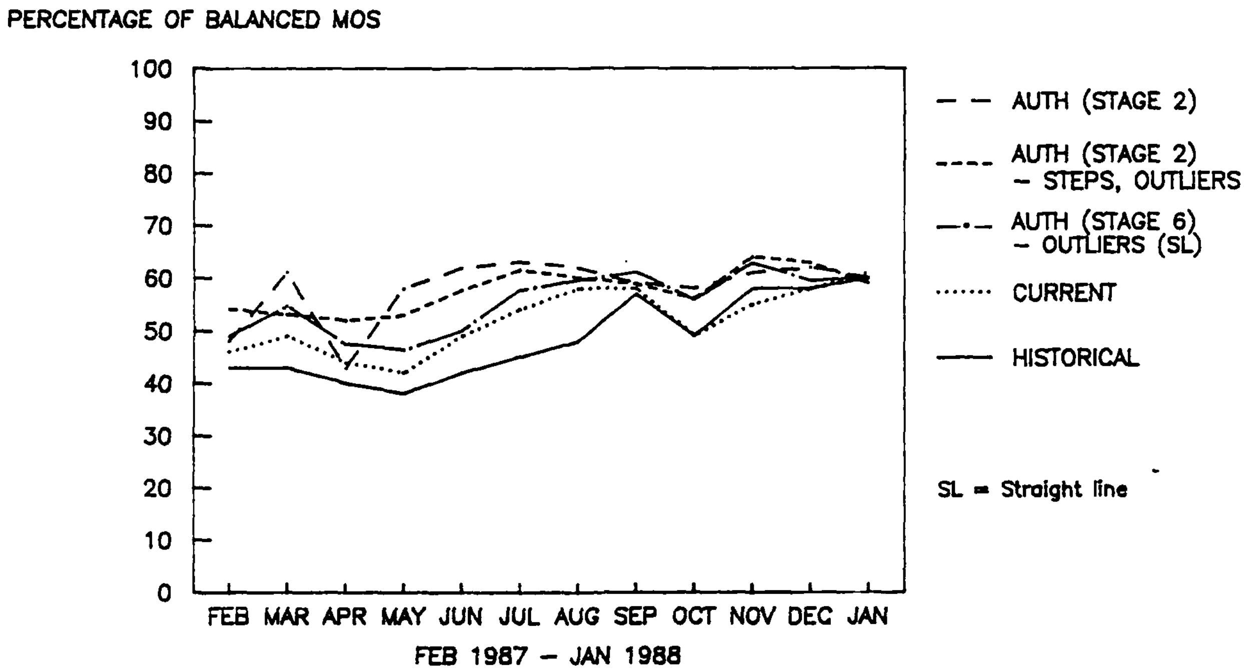


Figure 10-2. Comparing Target Generation Processes, Grade E5

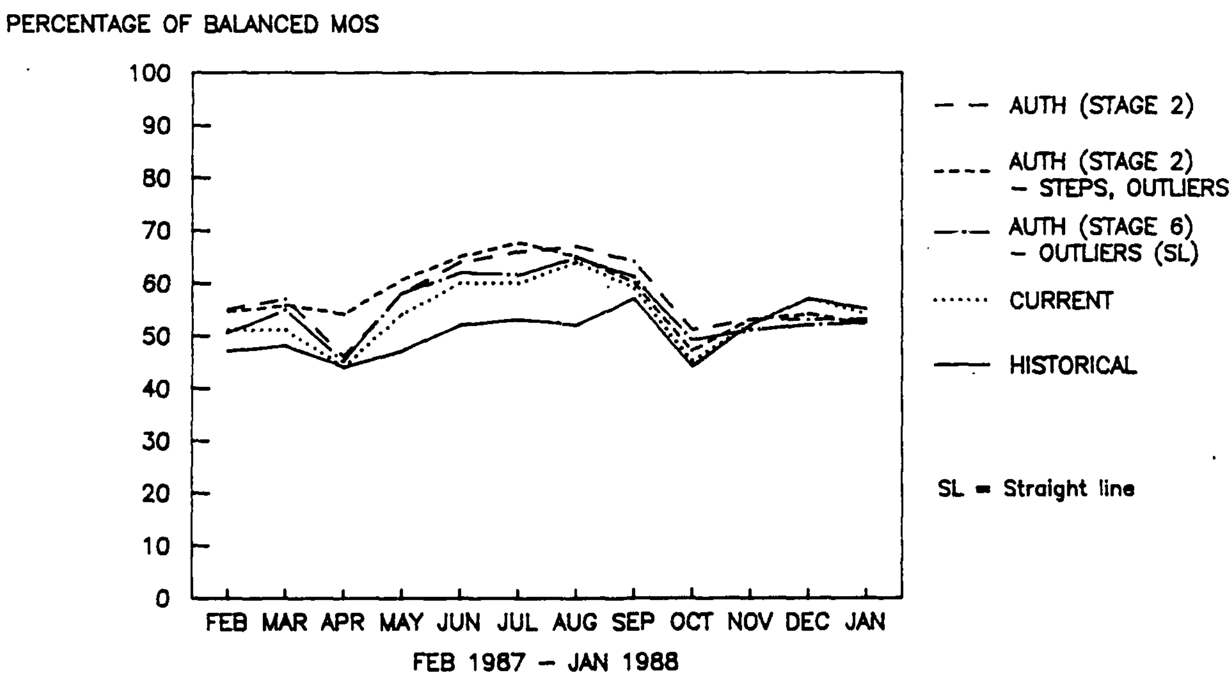


Figure 10-3. Comparing Target Generation Processes, Grade E6

b. Interpretation

(1) The current target generation process, in which authorizations are smoothed with a five-point weighted moving average ("current" targets), is distinctly superior to an earlier version of the same process, in which authorizations were smoothed using an exponential smoothing technique ("historical" targets). Based on 12 months of analysis "current targets" represent an improvement over "historical" targets by 4 percent balanced MOS in grade E5 and by 3 percent balanced MOS in grade E6. Also, average understrength per month is reduced by 258 soldiers per month, grade E5 and by 37 soldiers per month, grade E6. Average overstrength was reduced by 230 soldiers per month, grade E5, and 136 soldiers per month, grade E6.

(2) The current target generation process is slightly improved by still different statistical smoothing techniques. Smoothing authorizations using either the Tukey-Riffenberg or the ramp construction statistical techniques results in increased percentages of balanced MOS by 1 to 2 percent in grade E5 (no increase in grade E6) and reduction of percentages of MOS in categories of imbalance by 1 to 2 percent, grades E5 and E6. Of the two techniques, Tukey-Riffenberg and ramp construction, the greater improvement over the current smoothing technique occurs for Tukey-Riffenberg, which reduces average understrength by 57 soldiers per month, grade E5, and by 19 soldiers per month, grade E6; in addition, Tukey-Riffenberg is associated with reduction in average monthly overstrength by 17 soldiers per month, grade E5, and by 13 soldiers per month, grade E6.

(3) Of all target generation processes evaluated, the process which exists simply as stage 2 authorizations results in the greatest observed increase in percentages of balanced MOS relative to the current process (an increase of 6 percent, grade E5, and an increase of 3 percent, grade E6).

(4) Consistent superiority of the "stage 2 authorization" target generation process, relative to the current process, however, did not occur. Stage 2 authorizations were associated with accentuated underfill in grade E5 (3 percent more critically imbalanced MOS than in the current method) and an average number of 420 more soldiers per month understrength than for the current method. More overages also occurred for the stage 2 authorization relative to the current process in grade E5 (an average of 81 more soldiers per month). In grade E6, however, stage 2 authorizations were superior to current targets by an average of 32 fewer soldiers understrength and 22 fewer soldiers overstrength.

(5) A more complex version of the "stage 2 authorization" target generation process, selective smoothing of stage 2 authorizations identified as outliers and step functions, maintained the same high percentage of balanced MOS observed for the simpler version. Of all target generation processes compared, the complex version resulted in fewest shortages (594 fewer per month than the current target generation process in grade E5 and 521 fewer, grade E6). With regard to overstrength, however, selective smoothing of stage 2 authorizations identified as outliers and step functions produced an average of 464 more overages per month than did the current process in grade E5,and 219 more overages in grade E6.

(6) Small superiority to the current process in grade E5 did exist for "stage 6 authorizations", the target generation process which is identical to the current process except that smoothing of authorizations is eliminated. "Stage 6 authorizations" produced a 1 percent increase in percentage of balanced MOS, grade E5, a 1 to 2 percent decrease in percentage of imbalanced MOS, 18 fewer average numbers of soldiers understrength in grade E5, and 9 fewer overstrength, relative to the current process.

(7) A more complex version of the "stage 6 authorization" target generation process, was the "straightline smoothing of stage 6 authorizations identified as outliers." This more complex version improved the small superiority observed for the simpler version. Compared with the current process, percentages of balanced MOS were increased by 2 percent in both grades E5 and E6, and MOS in categories of underfill and overfill were decreased by 3 to 4 percent, also both grades. This straightline smoothing of stage 6 authorizations identified as outliers was the superior process in grade E5 if evaluated on the basis of number of shortages (59 fewer shortages per month than the current process) and number of overages (97 fewer per month than the current process).

10-4. RESPONSE TO EEA 5. Based on the comparison of distinct target generation processes drawn from alternate processes examined in Chapters 5-9, three processes have been identified which show superiority to the current process.

a. Stage 2 authorizations are superior with respect to percentages of balanced MOS; they are inferior, however, with respect to percentages of MOS which are critically imbalanced, underfill, and total numbers of shortages and overages.

b. Targets which also exist as stage 2 authorizations, but selectively smoothed for steps and outliers, maintained superiority of highest percentages of balanced MOS of all processes evaluated. In grade E5, this selective smoothing of stage 2 authorizations also resulted in greatest reduction of underfill, but it accentuated overfill.

c. In grade E6, the most effective target generation process, with respect to both highest percentages of balanced MOS and fewest shortages and overages, was the stage 2 authorizations.

d. In grade E5, the most effective target generation process was smoothing stage 6 authorizations identified as outliers. Although highest percentages of balanced MOS are not associated with such targets, they did produce the best distribution of percentages of MOS over categories of under and overfill and fewest shortages and overages observed in grade E5.

CHAPTER 11

OBSERVATIONS

11-1. THE SIMULATION

a. This has been a study on a total system. Distribution of operating fill resulting from alternate target generation processes was evaluated over all MOS in grades E5 and E6 for 12 successive months of simulating the E5/E6 promotion system. As many quantifiable complexities as were known were incorporated into the simulation. Results were evaluated based on distributions of MOS over categories of fill, as well as numbers of shortages and overaoes.

b. The disadvantage of such a study approach is that it is difficult to track the effect a given target has on operating strength through the many complexities of the system, to understand why a given target generation process may be better or worse. The advantage of such a study approach is that the magnitude of the effects of the alternate target processes with respect to the total system can be precisely established.

c. Clearly, the major finding based on the simulation of the total system is that operating fill can be maintained close to the authorization. The importance of fluctuations in the authorizations has been overrated. Promotions should be made relative to the authorization, not to some complex computational derivation of the authorization.

d. Additional work is needed to understand why the stage 2 authorization can lead to extremes in number of shortages or number of overages, even though distinctly superior results were obtained for the stage 2 authorization with respect to percentages of balanced MOS. Additional experimentation with the stage 2 authorization using the simulation would be profitable.

e. The simulation was useful in quantifying different components of the E5/E6 promotion system. It was established that the current analytical process of reducing numbers needed for promotion to required promotion ceilings was an effective process. It was also observed that discrepancies between the promotion determinations and actual numbers promoted does account for substantial reduction in balanced fill.

f. In additional experimentation based on the simulation, different statistical smoothing techniques were applied to an idealized promotion system in which a balanced force started the simulation, the constraining process of reducing numbers needed for promotion to promotion ceilings was removed, and promotion determinations were set to the actual numbers promoted. These results (not reported) simply increased percentages of balanced MOS and reduced MOS in categories of underfill, but it did not change the rankings of the different techniques relative to one another (i.e., the historical smoothing technique produced the lowest percentages of balanced MOS, the authorization stage 2 produced the highest, and the other techniques remained in between).

11-2. TARGET GENERATION PROCESSES

a. A concept motivating initiation of this study was that there are distinct patterns of fluctuations in authorizations and different statistical smoothing techniques should be effective for different patterns. Time was lost exploring this concept. Later in the study, the concept of a target was generalized from variations in statistical smoothing techniques to variations of the computational stages used in the current target generation process. Certainly, even more general variations of the target generation process could be developed and systematically evaluated.

b. The four to six computational stages of the current target generation process clearly washed out the effects of statistical smoothing of stage 2 authorizations. That statistical smoothing can be very powerful was demonstrated by the effect it had on the stage 2 authorization, when subsequent computations on the stage 2 authorization were eliminated. Statistical smoothing of steps and outliers in the stage 2 authorization substantially reduced underfill, maintained the high percentages of balanced MOS associated with the stage 2 authorization, but shifted imbalance in the direction of overfill.

c. Explaining the effect computational stages 4, 5, and 6 of the current target generation process has on fill is beyond the scope of this study. Authorizations are first moved up (inflated to total Army strength projections) and then back down to meet limitations by grade. In the middle of the contradictory computational process, projections of THS are incorporated. Little is known of the accuracy of these projections. What was observed about the current computational process, however, is that it does not lead to accentuated underfill or overfill. Stage 6 authorizations, smoothed for outliers, were associated with good distributions of MOS over all categories of fill; extremes in shortages and overages were not reported.

11-3. MEASURES OF FILL

a. Results were evaluated on the basis of four different variations of the measure, fill. Numbers and percentages of MOS in categories of fill ignore strength of the MOS in the different categories. Results showing strength of MOS in the different categories were, of course, also presented. Rather than computing total strength of MOS in each category, it would have perhaps been more informative to have computed total number of soldiers either understrength or overstrength in each of the categories.

b. Measurement dependent on category boundaries, which can be arbitrarily set, are always potentially misleading. Where so many changes in operating strength occur as a result of uncontrollable complexities which occur throughout the total E5/E6 promotion system, category boundaries as currently used appear to be overly refined.

c. One measure included in the study which was independent of category boundaries was total number of soldiers for which operating strength was less than authorized strength (shortages) and total number of soldiers for which operating strength was greater than authorized strength (overages). This measure was used throughout the study to supplement findings based on category boundaries.

11-4. TIMEFRAME FOR EVALUATION. A basic assumption of this study, of course, is that 12 months of analysis is sufficient for establishing findings. More than 12 months of analysis would have been desirable, if historical authorizations and targets had been available. Major structural changes occur to authorizations documents every 6 months, and 12 months of analysis is insufficient to adequately evaluate the effects of such changes. In addition, turbulence for all measures of the E5/E6 promotion system was observed for the first 7 months of the analysis timeframe; the system was more stable during the last 5 months. More analysis on how such turbulence relates to the findings would be desirable.

APPENDIX A

STUDY CONTRIBUTORS

1. STUDY TEAM

a. Study Director

Dr. Elizabeth N. Abbe, Force Systems Directorate

b. Team Members

CPT Eric M. Hughes
Ms. Kumud Mathur
Mr. Franklin E. Womack
Mr. Toivo Tagamets
Mr. Kenneth Martin
Mr. Michael Faraoni
Mr. David Smith

2. PRODUCT REVIEW BOARD

LTC Gerald Wilkes, Chairman
Mr. Art Williams
Mr. Jeff Hall
Ms. Tanya Peltz

3. EXTERNAL CONTRIBUTORS

MAJ John M. Hopkins, Force Alignment Plans and Analysis Division, Directorate of Military Personnel Management, Office of the Deputy Chief of Staff for Personnel, HQDA

LTC William F. Friese, Force Alignment Plans and Analysis Division, Directorate of Military Personnel Management, Office of the Deputy Chief of Staff for Personnel, HQDA

LTC Allan Marple, Force Alignment Plans and Analysis Division, Directorate of Military Personnel Management, Office of the Deputy Chief of Staff for Personnel, HQDA

CPT Ronald Higham, Force Alignment Plans and Analysis Division, Directorate of Military Personnel Management, Office of the Deputy Chief of Staff for Personnel, HQDA

Mrs. Susan Gatt, Accessions, Training, and Retention Management Division, Total Army Personnel Agency

Dr. Amir Eiger, Enlisted System Project Director, General Research Corps, McLean, VA

Mr. David Smyre, MOSLS Project Manager, General Research Corps, McLean, VA

APPENDIX B

STUDY DIRECTIVE

DEPARTMENT OF THE ARMY
OFFICE OF THE DEPUTY CHIEF OF STAFF FOR PERSONNEL
WASHINGTON, DC 20310-0300

REPLY TO ATTENTION OF
DAPE-MPF

6 JAN 1988

SUBJECT: E5/E6 Target Generation (TARGEN)--Study Directive

MEMORANDUM THRU: DEPUTY UNDER SECRETARY OF THE ARMY (OR)
ATTN: STUDY PROGRAM MANAGEMENT AGENCY

FOR: DIRECTOR, U.S. ARMY CONCEPTS ANALYSIS AGENCY

1. PURPOSE OF THE STUDY DIRECTIVE. This directive provides for the establishment of a study group for the subject study.

2. BACKGROUND.

a. Promotions into enlisted grades E5 and E6 are determined from a semi-centralized analytical system by individual MOS, by grade, for every month. The Military Personnel Management Directorate (DAPE-MP) of the Office of the Deputy Chief of Staff for Personnel (ODCSPER) provides policy direction for the system. The United States Total Army Personnel Agency (PROVISIONAL) (TAPA) operates the system, to determine the monthly promotions to E5 and E6 in each Military Occupational Specialty (MOS). Crucial input, in the form of projected trained strength targets for each MOS and grade, is provided by General Research Corporation (GRC) through the Military Occupational Specialty Level System (MOSLS) on FORECAST, the Headquarters Department of the Army Decision Support System.

b. A fundamental criterion for evaluating the effectiveness of the E5/E6 promotion system is based on the measurement of operating fill (operating strength divided by authorized personnel strength). Operating fill at or near to 100 percent in each MOS, in grades E5 and E6, for every month, and over successive months, is indicative of an effective system.

c. The process of maintaining operating fill has two distinct components: (1) generating targets from projected authorizations and (2) moving the operating strengths to the targets.

d. In the current operation of the E5/E6 promotion system, promotions are not determined relative to authorized strength, but to trained strength targets.

DAPE-MPF
SUBJECT: E5/E6 Target Generation (TARGEN)--Study Directive

e. Targets are adjusted projected authorizations. There are three major reasons for using targets in lieu of raw authorizations. The use of operating strength targets provides a capability to (1) correct known errors in the authorization data base, (2) account for undocumented personnel requirements (Space Imbalanced MOS (SIMOS), Directed Military Overstrength (DMO), and minimum authorized level of fill (MALOF) of selected units), and (3) provide for manning ramps with the appropriate lead time or lag time when authorizations are increasing or decreasing.

f. The E5/E6 Enlisted Promotion Model Study (EPM), February 1987, examined methodological improvements to the current E5/E6 strength. Targets, which historically determined model performance (April 1985-March 1986), formed the basis for evaluation. EPM was an examination of the link between operating strength and operating strength targets.

g. A study to evaluate the effectiveness of the target generation process with respect to maintaining operating fill--over all MOS, in grades E5 and E6, and over time--has not yet been performed. Nor has the potential of developing an optimal target generation process been fully explored. A study which focuses on the relationships between authorizations, targets, and the resulting operating strengths would be expected to satsify the Army's goal of fully investigating how the Army can improve the process of moving operating strength to authorized strength.

3. STUDY SPONSOR AND STUDY SPONSOR'S DIRECTOR. ODCSPER, COL G. L. Weigand.

4. STUDY AGENCY. U.S. Army Concepts Analysis Agency (CAA).

5. TERMS OF REFERENCE.

a. The Problem. To develop alternative methods of target generation for E5/E6 promotions, to compare these methods with the current method, and to identify the most effective method based on the measurement of fill (operating strength relative to authorized strength), over all MOS for enlisted grades E5 and E6.

(1) The effectiveness of the target generation process is dependent upon the authorization patterns of the MOS/grade cells. Two major types of MOS/grade cell patterns have already been identified. Approximately half of the cells

DAPE-MPF
SUBJECT: E5/E6 Target Generation (TARGEN)--Study Directive

in grades E5 and E6 have erratic authorizations over time. The other half exhibit relatively consistent authorizations.

(2) The evaluation of the target generation process needs to be expanded beyond consideration of appropriate smoothing techniques used to generate targets from projected authorizations. Nevertheless, a sophisticated procedure for applying the appropriate smoothing algorithm is a critical step in the target generation process.

(3) Adjustments in the target generation process to meet total strength constraints must take into account the availability of eligible soldiers, existence of overfill, differences between targets and the original authorizations, as well as the necessity to protect SIMOS, and other undocumented constraints.

b. Scope.

(1) This study will be limited to examination of analytical modifications pertaining to the target generation process of the current E5/E6 promotion system.

(2) Examination of the current and modified E5/E6 promotion system will be based on 12 consecutive simulations of the system for the 12 most recent months of available data within FY 1987-FY 1988 for approximately 300 E5 and 275 E6 MOS/grade cells. Affected MOS will be as specified in AR 611-201, dated October 1986, and updated accordingly during the period of the study.

(3) Evaluations of the current system and modifications to the current system will be based on fill (operating strength relative to target strength and operating strength relative to authorized strength). Different variations in the measurements of fill which will be applied to this study are:

- Numbers of MOS in different categories of fill.

- Strength in different categories of fill.

- Magnitude of understrength (the number of soldiers who are needed to fill MOS, over all MOS for which operating strength is less than target strength).

DAPE-MPF
SUBJECT: E5/E6 Target Generation (TARGEN)--Study Directive

- Magnitude of overstrength (the number of soldiers who exceed target strength, over all MOS for which operating strength is greater than target strength).

Categories of fill (as defined by the Army Enlisted Personnel Management Plan (EPMP), FY 1987-FY 1991) which will be applied to this study are:

- Number of critically imbalanced MOS, underfill: fill < = .80
- Number of moderately imbalanced MOS, underfill: .80 < fill < = .949
- Number of balanced MOS: .95 < = fill < = 1.049
- Number of moderately imbalanced MOS, overfull: 1.05 < = fill < = 1.199
- Number of critically imbalanced MOS, overfill: fill = > 1.2

c. Objectives.

(1) Evaluate the effectiveness of the current target generation process based on the measurement of fill (operating strength relative to authorized strength) of enlisted grades E5 and E6 over all MOS and over time.

(2) Develop and evaluate alternate methods of target generation based on the measurement of fill (operating strength relative to authorized strength) of enlisted grades E5 and E6 over all MOS and time.

d. Key Assumptions.

(1) The simulation of the E5/E6 promotion system based on 12 months of the most recent available data within FY 1987-1988 will be sufficient for evaluation purposes.

(2) Authorization patterns are sufficiently regular over time to permit effective application of statistical forecasting/smoothing techniques to the target generation process.

DAPE-MPF
SUBJECT: E5/E6 Target Generation (TARGEN)--Study Directive

e. Essential Elements of Analysis.

(1) How do targets, as currently generated, compare with authorizations based on the measurement of fill (operating strength relative to authorized strength) for all MOS, for enlisted grades E5 and E6, over time?

(2) What are the characteristics of those authorization patterns that produce large differences between operating strength, targets, and authorizations?

(3) What is the most effective method of generating targets for each pattern?

(4) If smoothing of the authorizations is appropriate, when in the target generation process should it be performed?

(5) How do alternative target generation processes compare with the current process based on the measurement of fill, for each MOS and grade pair for grades E5 and E6 over time?

(6) What are the effects of incorporating consideration of the availability of the soldiers eligible for promotion, the existence of overfill, the protection of space imbalanced MOS (SIMOS), and other constraints on fill, for each MOS at grades E5 and E6, over time?

f. Environmental and Threat Guidance. N/A.

g. Benefits. The study will result in a better understanding of how the procedures used in the target generation process affect personnel management program development and forecasting. The Army's ability to move personnel inventories to meet desired manning objectives while maintaining the Army's budgeted and authorized E5 and E6 strength should improve. Demonstrated improvements in the target generation process will be considered for inclusion in the target generator of the MOS Level System of FORECAST.

6. RESPONSIBILITIES.

a. ODCSPER will:

(1) Prepare an evaluation of the study results in accordance with AR 5-5.

DAPE-MPF
SUBJECT: E5/E6 Target Generation (TARGEN)--Study Directive

(2) Provide a list of Points of Contact (POC) for the Office of the Assistant Secretary of the Army (Manpower and Reserve Affairs); Headquarters, Department of the Army (HQDA); The United States Total Army Personnel Agency (Provisional) (TAPA); and other agencies as appropriate.

b. CAA will:

(1) Designate a study director and study team.

(2) Coordinate/communicate with appropriate commands/agencies for data necessary to accomplish the study.

(3) Provide periodic In-Process Reviews (IPR) as requested by ODCSPER and provide a final study report to the study sponsor.

(4) Provide experienced programming support for expanding the current CAA E5/E6 promotion Model to encompass the objectives/EEA and to update the data base.

(5) Provide technical consultation with a statistical forecasting specialist with expertise pertinent to development of improved target generation methodology.

c. Commander, TAPA will:

(1) Designate a POC as required.

(2) Provide personnel data and information as requested by CAA or ODCSPER. Provide all the data currently available NLT 31 October 1987. Provide final data NLT 29 January 1988.

(a) For FY87 and 88, provide monthly distributions (in machine readable format) of cutoff scores and the monthly enlisted promotion summary report.

(b) Provide machine readable E5/E6 promotion model output for the same time period.

(c) Provide other data or information as requested.

(3) Provide other input concerning promotion policies, procedures, capabilities and requirement as requested by CAA and ODCSPER.

DAPE-MPF
SUBJECT: E5/E6 Target Generation (TARGEN)--Study Directive

d. MOSLS Contracting Officer Representative, FORECAST will:

(1) Designate a POC as required.

(2) Provide authorization and target data (84 time units of projections) originating in FY86 and ending in FY88. Provide all data currently available NLT 31 October 1987. Provide final data NLT 29 January 1988.

(3) Provide other MOSLS data as requested by CAA.

(4) Provide technical information on the FORECAST/MOSLS system and on the current target generation process, in particular, as requested by CAA.

7. LITERATURE SEARCH.

Gardner, Everett S., Jr., Spyros Makridakis, and Steven Wheelwright, (Eds.), The Handbook of Forecasting, 2d Edition, John Wiley, New York, in press.

Granger, C.W.J. and Paul Newbold, Forecasting Economic Time Series, Academic Press, Inc., New York, 1977.

Holt, C.C., Forecasting Seasonals and Trends by Exponentially Weighted Moving Averages, Carnegie Institute of Technology, Pittsburgh, Pennsylvania, 1957.

Wheelwright, S.C. and S. Makridakis, Forecasting Methods for Management. John Wiley, New York, 1977.

Winters, P.R., Forecasting Sales by Exponentially Weighted Moving Averages, Management Science, 6, pp 324-342, 1960.

8. REFERENCES.

a. CAA Study Report CAA-SR-87-6, E5/E6 Enlisted Promotion Model (EPM) Study, February 1987.

b. AR 5-5, The Army Study System, 15 October 1981.

c. DA PAM 5-5, Guidance of Army Study Sponsors, Sponsor's Study Directors, Study Advisory Groups, and Contracting Officer Representatives, April 1982.

DAPE-MPF
SUBJECT: E5/E6 Target Generation (TARGEN)--Study Directive

d. AR 611-201, Enlisted Career Management Fields and Military Occupational Specialties, 25 October 1985.

e. The Army Enlisted Personnel Management Plan (FY 1987-91), Department of the Army, FY86 Edition.

9. ADMINISTRATION

a. Support.

(1) Funds for CONUS travel/per diem will be provided by the parent organization of each study participant.

(2) Clerical support will be provided by CAA.

(3) ADPE support for statistical analysis will be provided by CAA.

b. Milestone Schedule.

(1) Complete Study Plan; IPR	Oct 87
(2) Final Data Received from TAPA and FORECAST/MOSLS	Jan 88
(3) Interim Progress Review	Feb 88
(4) Final Results IPR	Jun 88
(5) Delivery of Draft Study Report to Sponsor	Jul 88

c. Control Procedures.

(1) ODCSPER will provide a Sponsor's Study Director for the study.

(2) ODCSPER will prepare and submit DD Form 1498 (Research and Technology Work Unit Summary) and final study documents to Defense Technical Information Center DTIC).

DAPE-MPF
SUBJECT: E5/E6 Target Generation (TARGEN)--Study Directive

d. Coordination. This directive has been coordinated with CAA IAW AR 10-38.

e. ODCSPER point of contact is MAJ John Hopkins, 693-2067.

FOR THE DEPUTY CHIEF OF STAFF FOR PERSONNEL:

Myrna H Williamson
MYRNA H. WILLIAMSON
Brigadier General, GS
Deputy Director of Military
Personnel Management

CF:
ASA(M&RA), ATTN: COL THIE
PA&E, ATTN: DACS-DPM (MAJ LEWIS)
ODCSPER IMO, ATTN: DAPE-ZXI-FC (CPT BASSINGER)
CDR, USTAPA (PROVISIONAL), ATTN: DAPC-PL (MAJ LOO)
CDR, USTAPA (PROVISIONAL), ATTN: DAPC-EPT-B (MRS. GATT)

APPENDIX C

BIBLIOGRAPHY

Abraham, Bovas and Johannes Ledolter, Statistical Methods ˉor Forecasting, John Wiley and Sons, Inc., New York, 1983

E5/E6 Enlisted Promotion Model (EPM), CAA-SR-87-6, US Army Concepts Analysis Agency, Bethesda, Maryland, February 1987

Gardner, Everette S., Jr., and Ed McKenzie, Forecasting Trends in Time Series, Management Science, 31, No. 10, October 1985

Holt, C. C., Forecasting Seasonals and Trends by Exponentially Weighted Moving Averages, Carnegie Institute of Technology, Pittsburgh, PA, 1957

Kang, C. A., D. D. Bedworth, and D. A. Rolier, Automatic Identification of Autoregressive Integrated Moving Average Time Series, IIE Transactions, 14, No. 3, September 1982

Law, Averill M., and W. David Kelton, Simulation Modeling and Analysis, McGraw-Hill Book Company, New York, NY, 1982

Montgomery, Douglas c., and Johnson A. Lywood, Forecasting and Time Series Analysis, McGraw-Hill Book Company, New York, NY, 1981

RIFELSM Methodology: Forecasting Rates for FAST, by Brad Rosbrook, Navy Personnel Research and Development Center, San Diego, CA

SPSS User's Guide, SPSS, Inc., McGraw-Hill Book Company, New York, NY, 1983

The Army Enlisted Personnel Management Plan (FY 1987-91), Department of the Army, FY 86 Edition

Winters, P. R., Forecasting Sales by Exponentially Weighted Moving Averages, Management Science, 6, pp 324-342, 1960

APPENDIX D

TECHNICAL DESCRIPTION OF ALTERNATE SMOOTHING TECHNIQUES

D-1. INTRODUCTION. This appendix provides more technical information on the alternate smoothing techniques presented in Chapter 3.

D-2. TUKEY-RIFFENBERG METHOD. Information concerning this smoothing technique was received from the Navy Personnel Research and Development Center (NPRDC). They are using this technique in their RIFELSM methodology in order to forecast rates for FAST, which is a simulation model designed to model the Navy's enlisted personnel system. Since we are trying to smooth authorizations and are not forecasting any rates the last procedure of their alogorithm, exponential smoothing, was not used in this study.

a. Smoothing by Medians of Threes. Smoothing by medians of threes is where consecutive moving groups of threes are formed which overlap the time series, and the median from each triplet is found. Special considerations are given to the end points since they have only one neighbor. The "medians" for the end points are calculated from the end point itself, the second median, and a third median computed from the two nearest medians of inner terms, using the formula (3xsecond - 2xthird) for the beginning of the series and (3xprevious - 2xnext previous) for the end of the series.

b. Hanning Smoother. Hanning works to average out the differences between "median" neighbors. End points are replaced by 75 percent of itself and 25 percent of its neighbor. Inner points receive 25 percent from each neighbor and 50 percent of itself.

D-3. WINTERS-HOLT

a. Description. Winters-Holt is a heuristic, three-parameter, exponential smoothing model. The general form of the Winters-Holt model (Granger and Newbold, 1977) expressed as an observation x_t at time t is as follows:

$$x_t = (a_1 + b_2 t)\, c_t + \varepsilon_t$$

The three parameters of the model are a_1, b_2, and c_t, while the term ε_t is taken to represent the ususal random error component. The parameter a_1 is called the permanent component and is analogous to the y-intercept (the level). This was calculated using the mean of the first cycle. The parameter b_2, or trend factor, corresponds to the slope of a simple linear equation. The third parameter, c_t, represents a set of seasonal factors for each cycle. The seasonal factors induce fluctuations above and below the line segments that are fitted to each cycle.

b. Smoothing Constants. Smoothing constants are required to combine previous estimates of parameters with their updated values. Numerical estimates of the permanent component, trend component, and the seasonal component get the weights α, β, and γ for the current interval t. The optimum smoothing constants were determined by trial and error. Different combinations of these parameters were varied for one MOS to provide the lowest root mean square error (RMSE). It turned out that all parameters were set to .1. This causes a slow response to changes in the data and more importantly to random fluctions. Ideally, we wanted to conduct a grid search for the optimum parameters; however, this was not feasible because of the amount of computer time needed for each of the approximately 250 MOS for each grade, and for each of the 12 months involved in this study.

D-4. REMOVAL OF OUTLIERS METHOD

a. The objective of this method is to remove high frequency noise from the authorizations. The methodology is very simple to apply, but the power of this method increases with how well one can define two parameters. These parameters are (1) a rate of change for a particular MOS and grade which would be disruptive to the normal response capability of the personnel management system, and (2) a period of time in months to discriminate between high frequency noise and normal manning patterns.

b. In the first part of the study, the rate of change parameter was specified in two different ways. First, a rate of 5 percent of the mean density of a particular MOS and grade was used as the maximum rate of change which, if exceeded in any one month, would lead to disruption in the personnel management system. This mean was calculated from the values of the Updated Authorization Document (UAD) for the particular MOS and grade in any given month. During discussions on this problem, there were several indications that a second method should be implemented which would incorporate this rate of change as a function of mean density. This second method calculates the maximum rate of change as a power function of mean density (i.e., [(mean density)$^{-0.6}$] x 100). This function is a model derived from a weighted regression of the maximum absolute change on a UAD to the mean density obtained on the UAD. The second method tends to be more sensitive to smaller changes in larger MOS/grades. The two methods intersect at a density of 150 personnel. Some example rates of the second method are (1) 25 percent (($10^{-0.6}$) x 100 = 25 percent) for density of 10 personnel, (2) 5 percent for density of 150 personnel, (3) 2.5 percent for 500 personnel, and (4) 0.5 percent for 7,000 personnel.

c. The second parameter which is used to discriminate between high frequency noise and normal manning patterns was set at 3 months. High frequency noise is identified on a UAD by locating rates of change which exceed the parameter value described above in the absolute value. For high frequency noise, one looks for at least two rates of change which exceed this value in a span of 3 months and which differed in sign. This is indicative of an authorization level which is maintained for less than 3 months. It is assumed that changes occurring in less than 3 months are noise and greater than 3 months are normal manning levels. This method directly relates to the Ramp method, which is further discussed in the following paragraphs.

D-5. RAMP METHOD

a. This smoothing algorithm consists of the following steps being applied to the data points for a particular UAD. First, the mean value is calculated and then the associated rate of change parameter is calculated as described in the removal of outliers method. The rates for the UAD are calculated by taking first differences of the UAD data. The differenced series is matched against the maximum rate parameter to identify high frequency noise.

Whenever a sequence of rates is encountered which would be indicative of high frequency noise, these rates are corrected. The rates are corrected by fitting a straight line between the authorizations adjacent to the point or points which are identified as noise. Only one or two points are so adjusted per sequence located, since the discrimination parameter is set at 3 months. After these noisy points are corrected, the new values at these points can be reevaluated, and the checking continues forward in time along the differenced series until the end is reached.

b. After the noise has been removed, the smoothing commences. Again, the points of the differenced series are sequentially checked against the maximum rate parameter. Since all of the high frequency noise was removed on the first pass, all that remains are normal manning levels (i.e., those manning levels which are sustained for 3 months or more). Any rate which exceeds the maximum rate parameter in absolute value on the second pass must be indicative of a rate change which would be disruptive to the normal operation of the personnel management system. Ramps are built to accommodate these manning levels so that neutral manning occurs. That is, the amount of over (under) manning at the beginning of the ramp for increasing (decreasing) authorizations should be equal to the under (over) manning at the end of the ramp. An increasing rate is corrected by first calculating the midpoint of the difference and then adjusting the preceding and succeeding months based on the maximum rate of change and the number of preceding months in the series to achieve an equal manning. A decreasing rate is corrected in the same manner; however, a loss rate for each MOS and grade is used instead of the maximum rate of change. This incorporates actual attrition rates from a particular MOS and grade in determining how many months in advance we should underman. Loss rates were provided by DCSPER for each MOS in each grade. It should be noted that it is possible to use different values of the maximum rate of change for the identification of noise and determining location of rate jumps, as well as the length of time used in discriminating between high frequency noise and normal manning levels.

APPENDIX E

MOS TRACKING

The timeframe for analyses in this study was from February 1987 to January 1988. If the operating strength and target strength of a MOS were both not zero in that grade cell for each of the 12 study months, it was considered as a valid MOS. Enlisted Promotion Summary Reports from TAPA for 12 months (8702-8801) were examined to check the validity of each MOS/grade cell. There were 265 MOS in E5 and 242 MOS in E6 selected. The validity of each MOS was then verified against the target authorization data provided by GRC. The list of valid MOS is given in Table E-1.

Table E-1. List of Valid MOS in E5 and E6 Grade Cells
(page 1 of 4 pages)

MOS		MOS		MOS	
E5	E6	E5	E6	E5	E6
00B	00B	11M	11M	---	18D
00J	00J	12B	12B	---	18E
00R	00R	12C	12C	---	18F
01H	01H	12E	12E	19D	19D
02B	02B	12F	12F	19E	19E
02C	02C	13B	13B	19K	19K
02D	02D	13C	13C	21G	21G
02E	02E	13E	13E	21L	21L
02F	02F	13F	13F	24C	24C
02G	02G	13M	13M	24G	24G
02H	02H	13N	13N	24H	24H
02J	02J	13R	13R	24J	24J
02K	02K	13T	13T	24K	24K
02L	02L	15E	15E	24L	24L
02M	02M	15J	15J	24M	24M
02N	02N	16D	16D	24N	24N
02S	02S	16E	16E	24T	24T
02T	02T	16H	16H	24U	24U
02U	02U	16J	16J	25L	25L
05D	05D	16P	16P	26T	26T
05H	05H	16R	16R	27B	27B
05K	05K	16S	16S	27E	27E
11B	11B	16T	16T	27F	27F
11C	11C	---	18B	27G	27G
11H	11H	---	18C	27L	27L

Table E-1. List of Valid MOS in E5 and E6 Grade Cells
(page 2 of 4 pages)

MOS		MOS		MOS	
E5	E6	E5	E6	E5	E6
27M	27M	35H	35H	45K	45K
27N	27N	35K	---	45L	---
29E	29E	35L	---	45N	---
29F	29F	35M	---	45T	---
29G	29G	---	35P	46N	46N
29H	29H	35R	---	51B	---
29J	29J	35U	35U	51G	---
29M	29M	36L	36L	---	51H
29N	29N	36M	36M	51K	---
29S	29S	39B	39B	51M	51M
29V	29V	41B	---	51R	---
29Y	29Y	41C	41C	---	51T
31C	31C	41E	---	52C	52C
31K	---	41J	41J	52D	52D
31M	31M	42C	42C	52E	52E
31N	31N	42D	42D	52F	52F
31V	---	42E	42E	52G	52G
32D	32D	43E	43E	55B	55B
33M	33M	43M	43M	55D	55D
33P	33P	44B	---	55G	55G
33Q	33Q	44E	44E	55R	55R
33R	33R	45B	---	---	55X
33T	33T	45D	---	57E	57E
33V	33V	45E	---	57F	57F
35G	---	45G	45G	62B	62B

Table E-1. List of Valid MOS in E5 and E6 Grade Cells
(page 3 of 4 pages)

MOS		MOS		MOS	
E5	E6	E5	E6	E5	E6
62E	---	66V	66V	71R	71R
62F	---	66Y	66Y	72E	72E
62G	62G	67G	67G	72G	72G
62H	62H	67H	67H	73C	73C
62J	---	67N	67N	73D	73D
---	62N	67R	67R	74D	74D
63B	63B	67S	67S	74F	74F
63D	63D	67T	67T	75B	75B
63E	63E	67U	67U	75C	75C
63G	---	67V	67V	75D	75D
63H	63H	67Y	67Y	75E	75E
63J	---	68B	68B	75F	75F
63N	63N	68D	68D	76C	---
63S	---	68F	68F	76J	76J
63T	63T	68G	68G	76P	76P
63W	---	68H	68H	76V	76V
63Y	---	68J	68J	76X	76X
66G	66G	68M	---	76Y	76Y
66H	66H	71C	71C	77F	77F
---	66J	71D	71D	77L	77L
66N	66N	71E	71E	77W	77W
66R	66R	71G	71G	81B	---
---	66S	71L	71L	81C	81C
66T	66T	71M	71M	81E	81E
66U	66U	71Q	71Q	81Q	81Q

Table E-1. List of Valid MOS in E5 and E6 Grade Cells
(page 4 of 4 pages)

MOS		MOS		MOS	
E5	E6	E5	E6	E5	E6
82B	---	91W	91W		
82C	82C	91X	91X		
82D	82D	91Y	91Y		
83E	---	92B	92B		
83F	83F	92E	92E		
84B	84B	93D	93D		
84C	---	93F	93F		
84F	84F	93H	93H		
91A	---	93J	93J		
91B	91B	93P	93P		
91C	91C	94B	94B		
91D	91D	94F	94F		
91E	91E	95B	95B		
91F	91F	95C	95C		
91G	91G	95D	95D		
91H	91H	96B	96B		
91J	91J	96D	96D		
91L	91L	96F	96F		
91N	91N	96H	96H		
91P	91P	96R	96R		
91Q	91Q	97B	97B		
91R	91R	97E	97E		
91S	91S	97G	97G		
91T	91T	98C	98C		
91U	91U	98G	98G		
91V	91V	98J	98J		

APPENDIX F

MEASURES OF FILL BY MONTH (8702-8801), GRADE E5 AND E6

Numbers, percentages, strength of MOS in five categories of fill, and total understrength and overstrength by month for target generation processes examined in Chapter 10 are available in the form of computer printouts. This data is available from CAA on request. Tables F-1 through F-10 presented in this appendix show examples of this computer printout for percentages of balanced MOS for 12 months of analysis (February 1987 - January 1988).

Table F-1. Percentage of MOS in Categories of Fill - Critically Under - Grade E5

Month	History	Current	Ramp	Auth Stage 6	Tukey	Auth Stage 6 outliers	Auth Stage 2	Auth (Stage 2) - steps, outliers	Auth Stage 2 outliers
8702	8	8	8	8	8	9	9	9	8
8703	8	8	8	8	8	8	9	8	8
8704	7	8	8	7	7	8	9	8	7
8705	2	2	2	2	2	3	8	6	2
8706	3	3	3	2	2	3	7	6	2
8707	3	3	3	3	3	3	6	5	3
8708	2	2	3	2	2	2	6	5	2
8709	2	2	3	2	2	3	6	2	2
8710	2	3	3	3	3	4	5	3	2
8711	2	2	2	2	2	2	4	1	2
8712	3	4	4	4	3	4	7	3	4
8801	2	2	3	3	2	3	6	2	3
Average	4	4	4	4	4	4	7	5	4

Table F-2. Percentage of MOS in Categories of Fill - Critically Under - Grade E6

Month	History	Current	Ramp	Auth Stage 6	Tukey	Auth Stage 6 outliers	Auth Stage 2	Auth (Stage 2) - steps, outliers	Auth Stage 2 outliers
8702	6	6	6	6	6	6	6	6	6
8703	6	6	6	6	6	6	6	6	6
8704	5	5	5	5	5	5	5	5	5
8705	4	3	3	3	3	3	5	2	3
8706	5	4	4	4	4	3	5	2	4
8707	2	3	3	2	2	2	4	1	2
8708	1	1	1	1	1	1	1	0	1
8709	1	1	1	1	1	1	1	0	1
8710	2	2	1	1	2	1	1	1	1
8711	2	2	2	2	2	2	1	1	2
8712	2	1	2	2	2	2	2	1	2
8801	1	1	2	2	2	1	1	1	2
Average	3	3	3	3	3	3	3	2	3

Table F-3. Percentage of MOS in Categories of Fill - Moderately Under - Grade E5

Month	History	Current	Ramp	Auth Stage 6	Tukey	Auth Stage 6 outliers	Auth Stage 2	Auth (Stage 2) - steps, outliers	Auth Stage 2 outliers
8702	26	23	23	22	23	21	23	16	22
8703	29	24	23	23	24	18	11	17	23
8704	29	25	25	26	25	20	24	13	26
8705	35	33	30	33	33	28	13	14	33
8706	31	27	28	27	27	25	10	11	28
8707	29	22	22	21	21	19	9	8	20
8708	27	18	15	14	16	17	8	8	14
8709	15	13	13	13	14	11	6	5	13
8710	20	18	12	14	14	12	7	5	13
8711	13	14	9	10	9	8	6	3	10
8712	10	9	9	11	9	10	5	4	10
8801	8	8	8	8	8	10	5	5	8
Average	23	19	18	19	19	17	11	9	18

Table F-4. Percentage of MOS in Categories of Fill - Moderately Under - Grade E6

Month	History	Current	Ramp	Auth Stage 6	Tukey	Auth Stage 6 outliers	Auth Stage 2	Auth (Stage 2) - steps, outliers	Auth Stage 2 outliers
8702	13	11	10	11	11	11	7	7	11
8703	10	8	7	7	7	6	4	4	7
8704	18	18	17	17	18	19	17	5	17
8705	14	10	9	9	9	8	7	3	9
8706	9	6	7	6	6	7	3	1	6
8707	8	7	7	7	7	8	2	0	7
8708	6	2	2	1	2	3	1	1	2
8709	4	3	4	2	3	4	1	1	3
8710	9	12	7	9	8	7	4	5	8
8711	5	6	4	5	4	7	3	2	5
8712	3	5	5	5	4	6	3	1	5
8801	2	3	4	5	4	4	2	1	5
Average	9	7	7	7	7	7	4	3	7

Table F-5. Percentage of MOS in Categories of Fill - Balanced - Grade E5

Month	History	Current	Ramp	Auth Stage 6	Tukey	Auth Stage 6 outliers	Auth Stage 2	Auth (Stage 2) - steps, outliers	Auth Stage 2 outliers
8702	43	46	47	49	48	49	49	54	49
8703	43	49	50	50	49	55	50	54	49
8704	40	44	44	43	44	48	43	52	43
8705	38	42	45	42	42	46	42	55	42
8706	42	49	47	48	49	50	48	58	47
8707	45	54	54	55	55	58	55	62	56
8708	48	58	60	60	59	60	60	60	60
8709	57	58	58	59	56	61	59	59	58
8710	49	49	55	54	53	56	54	56	54
8711	58	55	62	61	62	63	61	64	60
8712	58	58	60	58	61	59	58	63	57
8801	60	61	62	62	62	60	62	59	62
Average	48	52	54	53	53	55	53	58	53

Table F-6. Percentage of MOS in Categories of Fill - Balanced - Grade E6

Month	History	Current	Ramp	Auth Stage 6	Tukey	Auth Stage 6 outliers	Auth Stage 2	Auth (Stage 2) - steps, outliers	Auth Stage 2 outliers
8702	47	51	51	51	50	50	55	55	51
8703	48	51	51	52	51	55	57	56	52
8704	44	44	44	44	44	46	46	55	44
8705	47	54	54	55	54	59	58	61	55
8706	52	60	58	60	60	62	64	65	60
8707	53	60	58	60	60	62	66	68	60
8708	52	64	62	63	64	65	67	65	63
8709	57	59	55	59	57	62	64	61	59
8710	44	45	49	48	48	49	51	48	48
8711	52	52	52	52	55	52	53	53	52
8712	57	57	57	57	57	53	53	55	57
8801	55	54	50	51	50	53	53	52	51
Average	51	54	54	54	54	56	57	58	54

Table F-7. Percentage of MOS in Categories of Fill - Moderately Over - Grade E5

Month	History	Current	Ramp	Auth Stage 6	Tukey	Auth Stage 6 outliers	Auth Stage 2	Auth (Stage 2) - steps, outliers	Auth Stage 2 outliers
8702	11	12	11	11	11	10	9	10	11
8703	11	11	10	10	10	9	9	11	10
8704	12	13	13	13	13	14	12	16	13
8705	14	12	12	12	12	11	11	12	12
8706	13	10	11	11	10	11	11	14	12
8707	12	11	11	11	11	11	12	15	11
8708	13	13	13	14	14	12	14	17	14
8709	16	16	17	15	17	16	20	25	15
8710	17	17	17	17	17	16	17	22	17
8711	16	17	16	16	16	16	18	21	16
8712	18	17	17	17	16	17	16	19	17
8801	18	17	18	16	16	16	17	21	16
Average	14	14	14	13	14	13	14	17	14

Table F-8. Percentage of MOS in Categories of Fill - Moderately Over - Grade E6

Month	History	Current	Ramp	Auth Stage 6	Tukey	Auth Stage 6 outliers	Auth Stage 2	Auth (Stage 2) - steps, outliers	Auth Stage 2 outliers
8702	20	19	19	19	19	19	19	19	19
8703	22	22	22	21	22	20	20	22	21
8704	18	18	18	18	18	16	17	20	18
8705	22	20	21	20	21	17	17	22	20
8706	21	18	19	17	18	15	16	19	17
8707	23	19	19	19	19	18	17	18	19
8708	29	23	24	23	22	21	20	21	23
8709	25	25	28	25	27	21	22	25	25
8710	30	28	29	27	29	28	30	31	29
8711	29	28	30	29	28	27	29	29	28
8712	25	24	23	23	24	27	29	28	23
8801	28	27	29	27	29	27	28	27	27
Average	24	23	23	22	23	21	22	23	22

Table F-9. Percentage of MOS in Categories of Fill - Critically Over - Grade E5

Month	History	Current	Ramp	Auth Stage 6	Tukey	Auth Stage 6 outliers	Auth Stage 2	Auth (Stage 2) - steps, outliers	Auth Stage 2 outliers
8702	12	11	11	11	11	11	11	11	11
8703	10	9	9	9	9	9	9	9	9
8704	12	11	11	11	11	11	11	11	11
8705	11	11	11	11	11	11	11	13	11
8706	12	11	11	11	11	10	11	11	11
8707	11	11	10	11	11	9	9	10	11
8708	11	9	9	9	9	9	9	10	9
8709	11	11	10	11	11	9	9	9	11
8710	12	14	12	13	12	12	12	13	13
8711	11	12	11	11	11	10	10	11	12
8712	11	11	10	11	11	10	11	12	11
8801	11	12	10	11	11	11	11	12	12
Average	11	11	11	11	11	10	10	11	11

Table F-10. Percentage of MOS in Categories of Fill - Critically Over - Grade E6

Month	History	Current	Ramp	Auth Stage 6	Tukey	Auth Stage 6 outliers	Auth Stage 2	Auth (Stage 2) - steps, outliers	Auth Stage 2 outliers
8702	14	14	14	14	14	14	14	14	14
8703	14	14	14	14	14	13	13	13	14
8704	15	15	15	15	15	15	15	15	15
8705	13	13	13	14	13	13	14	14	14
8706	14	12	12	13	12	12	12	13	13
8707	13	12	12	12	12	11	10	12	12
8708	12	11	11	12	11	11	11	13	12
8709	14	12	12	13	12	12	12	13	13
8710	14	14	14	14	14	15	14	16	14
8711	13	12	12	13	12	13	14	15	13
8712	13	13	14	14	13	13	13	15	14
8801	14	15	15	16	15	16	16	19	16
Average	13	13	13	14	13	13	13	14	14

APPENDIX G

IDENTIFICATION OF SEASONALITY

G-1. INTRODUCTION. This appendix discusses the statistical procedures used to identify seasonal patterns within projected personnel authorizations.

G-2. CLASSIFICATION OF DATA. A series of data can be identified as being seasonal by two different statistical measures: (1) order of nonseasonal differencing and (2) the maximum lag of the sample autocorrelation function which is statistically significant using Bartlett's approximation of large-lag standard error criteria. Subparagraphs a through k describe the calculations needed to compute these statistical measures.

a. Number of observations used in calculations.

b. Month in which the lowest or highest monthly average occurred. Value selected on the basis of the two differences, highest minus second highest or least minus second least.

c. Difference between monthly average selected in b above and the average of the data from the remaining 11 months. This measure should be used in coordination with measure j below to see if this difference occurs such as to divide the 12 months into two distinct sets, one including only the month indicated in b above and the other set containing the remaining 11 months. If the indictor in j below is a 1 or -1, one can assume one has so divided the 12 months into such a set.

d. Relative error of the monthly mean selected in b above expressed as a percentage of the overall mean of the 48 observations.

e. Differencing required to make series stationary. Test for stationary based on the ratios of the first four autocorrelations (i.e., R2/R1, R3/R3, and R4/R3. Kang describes this as a rough automated way to detect nonstationary.

f. Largest significant autocorrelation calculated using Bartlett's approximation and considering significant any autocorrelation greater than two times the large-lag standard error. If value is smaller than the largest number of autocorrelations calculated, then the number reflects the last significant sample autocorrelation calculated.

g. Inflation or deflation factor in calculating the sample variance given a covariance stationary process and assuming that the sample autocorrelations measured are in fact good (reference to Law and Kelton).

h. Assuming a two-way of analysis of variance model is appropriate to analyze the differenced stationary series, this indicator variable indicates whether there is a significant difference in the monthly means as calculated in b and c above. A 1 indicates significance at alpha = 5 percent, a 2 at alpha = 1 percent, and a 3 at alpha = 0.1 percent. Zero indicates no significant difference.

i. Assuming same ANOVA model as in h above, this indicator variable provides similar information about the four yearly means. The alternate hypothesis is that there is a level shift in at least one of the 4 years.

j. An indicator variable which indicates whether the largest difference calculated between the ranked monthly means occurs between the highest value and the second highest value as indicated by a value of 1, or between the least value and the second least value as indicated by -1, or between any of the other ranked values indicated by 0. The latter case would tend to indicate that the monthly means can be divided into at least two sets where each set contains more than one member. This would tend to indicate that there is no overall month distinct from the remaining months.

k. The first 13 sample autocorrelations.

The following is a worked example for MOS 11B starting in month 8709. The order of processing will be as described in the above list. The first 48 observations were used in all of the calculations. If differences were used as is the case here, the length remained 48. The observations for this set are listed below.

Table G-1. Worked Sample, MOS 11B, Starting Month 8709

Month	1st year	2d year	3d year	4th year	Total
Sep	7445	7182	7012	6642	28281
Oct	7382	7166	7018	6642	28208
Nov	7450	7166	7018	6642	28276
Dec	7457	7166	7018	6642	28283
Jan	7379	7160	7018	6564	28121
Feb	7301	7160	7018	6564	28043
Mar	7301	7160	7018	6564	28043
Apr	7224	7160	7018	6564	27966
May	7220	7228	7018	6486	27952
Jun	7220	7222	6940	6408	27790
Jul	7220	7144	6940	6408	27712
Aug	7220	7043	6781	6251	27295

Parameters b and j above give an indication of the month in which the lowest or highest value occur and whether this month stands in isolation of the other months. In Table G-2, the totals have been reordered from smallest to largest and the difference taken.

Table G-2. Differences of Monthly Totals

Month	Total	Difference
Aug	27295	
Jul	27712	417
Jun	27790	78
May	27952	162
Apr	27966	14
Mar	28043	77
Feb	28043	0
Jan	28121	78
Oct	28208	87
Nov	28276	68
Sep	28281	5
Dec	28283	2

The smallest total occurs in August and the largest in December. The largest difference at the small end is 417. This would give j a value of -1. If this difference had occurred somewhere else in the ordered sequence, it would not indicate that one value stands out alone as August does in this case. If the largest difference occurs in the middle, the indicator variable j is 0, and if on the large end +1. The absolute and relative errors associated with this point are calculated in Table G-3.

Table G-3. Computations for Absolute Relative Error

$$Absolute\ error \sum_{i=1}^{12} \sum_{j=1}^{4} Zij/44 = 7015$$

$$For\ i = 8\ (August) \sum_{j=1}^{4} Z8j/4 = 6824$$

$$Absolute\ error = 6824 - 7015 = |-191| = 191$$

$$Overall\ mean = \sum_{i=1}^{12} \sum_{j=1}^{4} Zij/48 = 6999$$

$$Relative\ error\ (in\ percent) = \frac{Absolute\ error}{Overall\ mean} = \frac{191}{6999} x\ 100 = 2.73$$

where Z_{ij} = observation in ith month, jth year.

The series must be stationary before the autocorrelation function can be evaluated. The usual method of determining stationary is to look at the autocorrelation function of the series. If the autocorrelation function damps out slowly, then the series needs differencing. Usually several orders of both nonseasonal and seasonal differencing are evaluated. In this particular example, the need for differencing is indicated by the declining trend in the data. In a paper by Kang, a simple heuristic is described which can automate this visual process. For nonseasonal differencing, the ratios of the first four autocorrelations are formed. These take the form r1/r2, r2/r3, and r3/r4. If the value of each of these ratios exceeds 0.8, the series should be differenced. Moreover, the same ratios of the newly differenced series are checked for further differencing. In the case of seasonal data, Kang recommends the value 0.6. In this example, first order differencing is indicated. Out of a group of these series evaluated using the data provided, about 39 percent required no differencing, 55 percent required first differences, and 3 percent required second differences. Another 3 percent were at one constant level.

The first 16 autocorrelations are shown in Table G-4. The calculation formulae for the sample autocovariance, the sample autocorrelation, and the large-lag standard error are listed below.

Table G-4. Formulae for Autocovariance, Autocorrelation and Large-lag Standard Error

$$\text{Sample autocovariance: } C_k = \frac{1}{N}\sum_{t=1}^{N-k}(Z_t - \bar{Z})(Z_{t+k} - \bar{Z}),\ k = o,1,2,\ldots,K$$

$$\text{Sample autocorrelation: } r_k = \frac{c_k}{c_o}$$

$$\text{Bartlett's large-lag standard error: } var[r_k] = \frac{1}{N}\left\{1 + 2\sum_{v=1}^{q} r_v^2\right\},\ k > q$$

where: Z_t = observed value; Z = overall mean
c_k = sample autocovariance at lag k
r_k = sample autocorrelation at lag k
N = number of observations

The following data (Table G-5) are the first 16 autocorrelations for the above series differenced once. The first column is the lag, followed by the sample autocorrelation, twice the large-lag standard error. It is concluded from this series that at least the 12th lag autocorrelation is significant.

Table G-5. Autocorrelations

Lag	Sample autocorrelation coefficient	2*Large-lag standard error
1	.20	.29
2	-.07	.30
3	-.14	.30
4	-.01	.31
5	-.06	.31
6	-.15	.31
7	-.01	.31
8	-.04	.31
9	.06	.31
10	-.01	.32
11	.18	.32
12	.37	.32
13	.08	.36
14	.07	.36
15	-.17	.37
16	-.16	.37

The next parameter calculated is a correction factor to correct the variance of a sample mean for autocorrelated data. It is described in the text by Law and Kelton. For this data set, the value calculated is 1.45. This would tend to reduce the size of the sample variance for this data set. A two-way analysis of variance was constructed to determine if the effects of (1) months or (2) years were statistically significant. In this case, shown in Table G-6, the monthly effect is significant at the alpha = 0.05 level.

Table G-6. ANOVA Table

Effect	Sum of squares	DF	Mean square	F-value
Years	6257	3	2086	1.09
Months	44783	11	4071	2.12
Error	63279	33	1918	

APPENDIX H

PATTERN RESULTS FOR GRADE E6

This appendix contains tables of results for grade E6 which parallel grade E5 tables in Chapters 6 and 7. Tables H-1 through H-8 provide grade E6 results for the different patterns identified in Chapter 6. Tables H-9 through H-17 provide grade E6 results identifying the best smoothing techniques for each pattern, similar to Chapter 7. In these tables, both the "historical" and the "current" methods are presented, along with the methods which showed the highest percentage of balanced MOS.

Table H-1. Impact of Authorization Size on Number of Balance MOS, Grade E6

Authorization size	Average number of balanced MOS	Percent balanced MOS	Average number of OBS
< 20	3	16	19
20 - 50	18	39	46
50 - 100	24	52	46
> 100	86	66	131
Overall	131	54	242

Table H-2. Impact of Outlier on Number of Balanced MOS, Grade E6

Outliers	Avg no of balanced MOS	Percent balanced MOS	Avg no of observations
Effecting target	1	100	1
Not effecting target	8	73	11
Other	122	53	230
Overall	131	54	242
Occurring in September	5	71	7
Other	126	54	235
Overall	131	54	242

Table H-3. Impact of Steps on the Number of Balanced MOS, Grade E6

Steps	Avg no of balanced MOS	Percent balanced MOS	Avg no of observations
Beyond first FY	75	54	140
Ascending	22	61	36
Descending	26	61	43
Other	8	35	23
Overall	131	54	242

Table H-4. Impact of Seasonality on the Number of Balanced MOS, Grade E6

Seasonality	Avg no of balanced MOS	Percent balanced MOS	Avg no of observations
Most indication of	6	55	11
Other	125	54	231
Overall	131	54	242

Table H-5. Impact of Ascending/Descending Patterns of Number of Balanced MOS, Grade E6

Ascending/descending patterns	Avg no of balanced MOS	Percent balanced MOS	Avg no of observations
Ascending/ascending	30	58	52
Descending/descending	27	66	41
Mixed slope	74	50	149
Overall	131	54	242

Table H-6. Impact of Turbulence on the Number of Balanced MOS, Grade E6

Turbulence	Avg no of balanced MOS	Percent balanced MOS	Avg no of observations
Coefficient of variation < .1 (low)	112	58	198
Coefficient of variation > .1 (high)	19	43	44
Overall	131	54	242

Table H-7. Impact of Turbulence with Ascending/Descending Patterns on the Number of Balanced MOS, Grade E6

Turbulence	Avg no of balanced MOS	Percent balanced MOS	Avg no of observations
With high turbulence:			
Ascending/ascending	1	25	4
Descending/descending	1	25	9
Mixed slope	3	33	9
With low turbulence:			
Ascending/ascending	29	60	48
Descending/descending	26	70	37
Mixed slope	71	51	140
Overall	131	54	242

Table H-8. Impact of Patterns Across UAD on the Number of Balanced MOS, Grade E6

Cross UAD	Avg no of balanced MOS	Percent balanced MOS	Avg no of observations
Turbulence:			
Low	118	54	220
High	3	14	22
Overall	121	50	242
Slope:			
Descending	17	39	44
Level	74	50	147
Ascending	30	59	51
Overall	121	50	242
Percent error:			
> 5 (increasing auth)	2	15	13
≤ 5	115	53	216
< 5 (decreasing auth)	4	31	13
Overall	121	50	242

Table H-9. Effects o. Authorization Size - Percentage of MOS in Categories of Fill (8702-8801), Grade E6

Mean authorization ≤ 20
(19 MOS/month)

Target process	Critically under	Moderately under	Balanced	Moderately over	Critically over	Total
Historical	10	7	14	11	58	100
Current	7	10	18	11	54	100
Auth (Stage 6)	6	12	16	13	53	100
Auth (Stage 2)	6	6	25	13	50	100

20 < Mean authorization ≤ 50
(46 MOS/month)

Historical	6	11	35	33	15	100
Current	6	11	39	30	14	100
Auth (Stage 6)	6	10	40	29	15	100
Auth (Stage 2)	7	5	44	28	16	100

50 < Mean authorization ≤ 100
(46 MOS/month)

Target process	Critically under	Moderately under	Balanced	Moderately over	Critically over	Total
Historical	3	12	46	26	13	100
Current	2	8	51	26	13	100
Outlier (moving avg)	3	8	50	26	13	100
Auth (Stage 2)	2	7	54	24	13	100

100 < Mean authorization
(131 MOS/month)

Historical	1	7	63	22	7	100
Current	1	5	66	21	7	100
Ramp	2	5	66	21	6	100
Auth (Stage 2)	2	3	68	20	7	100

Table H-10. Identification of Outliers - Percentage of MOS in Categories of Fill (8702-8801), Grade E6

Identification of outliers affecting the target month
(1 MOS/month)

Target process	Critically under	Moderately under	Balanced	Moderately over	Critically over	Total
Historical	0	0	100	0	0	100
Current	0	0	100	0	0	100
Auth (Stage 2)	0	0	100	0	0	100
Tukey	0	0	100	0	0	100

Identification of outliers in September
(7 MOS/month)

Target process	Critically under	Moderately under	Balanced	Moderately over	Critically over	Total
Historical	0	6	60	28	6	100
Current	0	8	69	17	6	100
Tukey	0	3	70	21	6	100
Auth (Stage 2)	0	7	71	16	6	100

Table H-11. Identification of Steps - Percentage of MOS in Categories of Fill (8702-8801), Grade E6

Ascending steps
(36 MOS/month)

Target process	Critically under	Moderately under	Balanced	Moderately over	Critically over	Total
Historical	1	10	55	19	16	100
Current	1	17	54	15	14	100
Outlier (MA)	0	5	66	18	11	100
Auth (Stage 6)	0	5	66	18	11	100
Auth (Stage 2)	0	3	68	18	11	100

Descending steps
(50 MOS/month)

Target process	Critically under	Moderately under	Balanced	Moderately over	Critically over	Total
Historical	0	13	54	17	14	100
Current	0	6	60	19	15	100
Tukey	0	6	60	20	14	100
Auth (Stage 2)	0	3	63	19	15	100

Legend: MA = moving average.

Table H-12. Identification of Seasonality - Percentage of MOS in Categories of Fill (8702-8801), Grade E6

(11 MOS/month)

Target process	Critically under	Moderately under	Balanced	Moderately over	Critically over	Total
Historical	1	7	56	25	11	100
Current	0	9	58	23	10	100
Ramp	0	5	63	22	10	100
Outlier (MA)	0	4	63	22	11	100

Table H-13. Effects of Authorization Slopes - Percentage of MOS in Categories of Fill (8702-8801), Grade E6

Ascending/ascending pattern
(52 MOS/month)

Target process	Critically under	Moderately under	Balanced	Moderately over	Critically over	Total
Historical	1	5	54	28	12	100
Current	1	7	58	23	11	100
Ramp	1	6	57	25	11	100
Tukey	1	6	58	24	11	100
Auth (Stage 2)	2	4	58	25	11	100

Descending/descending pattern
(41 MOS/month)

Target process	Critically under	Moderately under	Balanced	Moderately over	Critically over	Total
Historical	3	9	63	12	13	100
Current	2	5	65	15	13	100
Tukey	1	5	65	16	13	100
Auth (Stage 6)	2	4	64	17	13	100
Auth (Stage 2)	2	2	68	16	13	100

Mixed slopes
(149 MOS/month)

Target process	Critically under	Moderately under	Balanced	Moderately over	Critically over	Total
Historical	4	9	46	27	14	100
Current	4	8	50	24	14	100
Auth (Stage 6)	4	8	50	24	14	100
Auth (Stage 2)	4	6	54	23	14	100

Table H-14. Turbulence Across Authorization Documents from Month i to Month i+2 - Percentage of MOS in Categories of Fill (8702-8801), Grade E6

Low turbulence across authorization documents
(217 MOS/month)

Target process	Critically under	Moderately under	Balanced	Moderately over	Critically over	Total
Historical	3	10	51	25	11	100
Current	3	9	54	24	11	100
Outlier (SL), M	3	8	54	24	11	100
Tukey	3	8	54	25	11	100
Auth (Stage 2)	3	7	56	23	11	100

High turbulence across authorization documents
(25 MOS/month)

Target process	Critically under	Moderately under	Balanced	Moderately over	Critically over	Total
Current	11	21	14	14	40	100
Historical	11	23	14	14	38	100
Outlier (SL), M	10	23	15	14	38	100
Auth (Stage 2)	8	18	22	14	38	100

Table H-15. Slope Across Authorization Documents from Month i to Month i+2 - Percentage of MOS in Categories of Fill (8702-8801), Grade E6

Descending pattern across authorization documents
(44 MOS/month)

Target process	Critically under	Moderately under	Balanced	Moderately over	Critically over	Total
Historical	3	6	41	30	20	100
Current	4	4	39	33	20	100
Tukey	4	4	40	32	20	100
Auth (Stage 6)	4	4	40	32	20	100
Auth (Stage 2)	4	3	41	31	21	100

Level pattern across authorization documents
(154 MOS/month)

Target process	Critically under	Moderately under	Balanced	Moderately over	Critically over	Total
Historical	4	9	46	26	15	100
Current	3	7	50	25	14	100
Ramp	3	7	50	26	14	100
Tukey	3	7	51	25	14	100
Auth (Stage 2)	4	5	54	23	14	100

Ascending pattern across authorization documents
(44 MOS/month)

Target process	Critically under	Moderately under	Balanced	Moderately over	Critically over	Total
Historical	5	23	55	13	5	100
Current	4	23	58	10	5	100
Ramp	4	21	59	11	5	100
Auth (Stage 2)	3	19	62	12	4	100

Table H-16. Percent Change Across Authorization Documents from Month i to Month i+2 - Percentage of MOS in Categories of Fill (8702-8801), Grade E6

> 5 percent (increasing authorization)
(51 MOS/month)

Target process	Critically under	Moderately under	Balanced	Moderately over	Critically over	Total
Historical	5	23	55	13	5	100
Current	4	23	58	10	5	100
Auth (Stage 6)	4	20	60	11	5	100
Auth (Stage 2)	3	19	62	12	4	100

> 5 percent (decreasing authorization)
(44 MOS/month)

Historical	3	6	41	30	20	100
Current	4	4	40	32	20	100
Auth (Stage 6)	4	4	40	32	20	100
Auth (Stage 2)	4	3	41	31	21	100

≤ 5 percent change
(216 MOS/month)

Historical	3	10	50	24	13	100
Current	3	8	53	23	12	100
Outlier (Str - line)	3	8	54	23	13	100
Auth (Stage 6)	3	8	54	23	13	100
Auth (Stage 2)	3	5	57	21	13	100

Table H-17. Comparison of Smoothing Techniques in Target Generation - Percentage of MOS in Categories of Fill (8702-8801), Grade E6

Target process	Category of fill					
	Critically under	Moderately under	Balanced	Moderately over	Critically over	Total
Historical	3	9	51	24	13	100
Winters	3	8	48	27	14	100
Current	3	8	54	22	13	100
Tukey & outlier	3	7	54	23	13	100
Outlier (str - line)	3	7	54	22	14	100
Auth (Stage 6)	3	7	54	22	14	100
Tukey	3	7	54	23	11	100
Outlier (MA)	3	7	54	23	13	100
Ramp	3	7	54	23	13	100
Auth (Stage 2)	3	5	57	22	13	100

APPENDIX I

MEASURES OF FILL, AVERAGES PER MONTH (8712-8801), GRADES E5 AND E6

This appendix provides complete sets of table results for the analysis presented in this study for both grades E5 and E6. The tables are organized as follows:

Tables	Titles
I-1 through I-8	Comparison of Smoothing Techniques
I-9 through I-16	Smoothing Order Comparisons
I-17 through I-24	Protecting Selected Authorizations
I-25 through I-32	Effects of Selective Smoothing Processes
I-33 through I-40	Comparison of Target Generation Processes

Each set of tables includes the number, percentage, and density of MOS in the different categories of fill, as well as the average strength of MOS in understrength and overstrength.

Table I-1. Comparison of Smoothing Techniques in Target Generation Number of MOS in Categories of Fill (8702-8801)
Grade E5

TARGET PROCESS \ CATEGORY OF FILL	CRITICALLY UNDER	MODERATELY UNDER	BALANCED	MODERATELY OVER	CRITICALLY OVER	TOTAL
WINTERS	12	56	127	42	29	265
HISTORICAL	10	60	128	37	30	265
CURRENT	10	52	137	37	29	265
TUKEY & OUTLIER	10	49	140	37	29	265
OUTLIER (STR-LINE)	10	49	141	36	29	265
AUTH (STAGE 6)	10	49	141	36	29	265
TUKEY	10	49	141	36	29	265
OUTLIER (MOVING AVG)	10	49	142	36	29	265
RAMP	11	48	142	37	28	265
AUTH (STAGE 2)	18	28	154	37	28	265

Table I-2. Comparison of Smoothing Techniques in Target Generation Number of MOS in Categories of Fill (8702-8801)
Grade E6

TARGET PROCESS \ CATEGORY OF FILL	CRITICALLY UNDER	MODERATELY UNDER	BALANCED	MODERATELY OVER	CRITICALLY OVER	TOTAL
WINTERS	8	19	117	65	33	242
HISTORICAL	8	21	122	59	33	242
RAMP	7	17	130	57	32	242
CURRENT	7	18	131	55	32	242
OUTLIER (STR-LINE)	7	17	131	54	33	242
AUTH (STAGE 6)	7	17	131	54	33	242
TUKEY	7	17	131	55	32	242
OUTLIER (MOVING AVG)	7	16	131	55	33	242
TUKEY & OUTLIER	7	17	132	55	32	242
AUTH (STAGE 2)	8	11	139	53	32	242

Table I-3. Comparison of Smoothing Techniques in Target Generation
Percentage of MOS in Categories of Fill (8702-8801)
Grade E5

TARGET PROCESS \ CATEGORY OF FILL	CRITICALLY UNDER	MODERATELY UNDER	BALANCED	MODERATELY OVER	CRITICALLY OVER	TOTAL
HISTORICAL	4	23	48	14	11	100
WINTERS	4	21	48	16	11	100
CURRENT	4	20	52	14	11	100
TUKEY & OUTLIER	4	19	53	14	11	100
OUTLIER (STR. - LINE)	4	19	53	14	11	100
AUTH (STAGE 6)	4	19	53	13	11	100
TUKEY	4	19	53	14	11	100
OUTLIER (MOVING AVG)	4	18	53	14	11	100
RAMP	4	18	54	14	11	100
AUTH (STAGE 2)	7	11	58	14	11	100

Table I-4. Comparison of Smoothing Techniques in Target Generation
Percentage of MOS in Categories of Fill (8702-8801)
Grade E6

TARGET PROCESS \ CATEGORY OF FILL	CRITICALLY UNDER	MODERATELY UNDER	BALANCED	MODERATELY OVER	CRITICALLY OVER	TOTAL
WINTERS	3	8	48	27	14	100
HISTORICAL	3	9	51	24	14	100
CURRENT	3	8	54	23	13	100
TUKEY & OUTLIER	3	7	54	23	13	100
OUTLIER (STR. - LINE)	3	7	54	22	14	100
AUTH (STAGE 6)	3	7	54	22	14	100
TUKEY	3	7	54	23	13	100
OUTLIER (MOVING AVG)	3	7	54	23	14	100
RAMP	3	7	54	23	13	100
AUTH (STAGE 2)	3	5	57	22	13	100

Table I-5. Comparison of Smoothing Technniques in Target Generation
Density of MOS in Categories of Fill (8702-8801)
Grade E5

CATEGORY OF FILL / TARGET PROCESS	CRITICALLY UNDER	MODERATELY UNDER	BALANCED	MODERATELY OVER	CRITICALLY OVER	TOTAL
HISTORICAL	1,412	27,239	63,162	9,923	4,652	106,388
WINTERS	2,926	24,558	63,625	10,263	4,995	106,367
CURRENT	2,198	24,600	67,410	7,629	4,579	106,417
TUKEY & OUTLIER	1,410	23,693	68,688	8,308	4,330	106,429
OUTLIER (STR. - LINE)	1,226	24,024	68,468	8,121	4,597	106,436
AUTH (STAGE 6)	1,227	24.154	68,457	8,004	4,583	106,425
TUKEY	1,233	23,490	69,259	7,793	4,501	106,456
OUTLIER (MOVING AVG)	1,226	23,790	68,831	8,000	4,591	106,437
RAMP	2,865	22,250	69,036	8,160	4,085	106,395
AUTH (STAGE 2)	4,338	10,856	79,449	6,857	4,577	106,077

Table I-6. Comparison of Smoothing Technniques in Target Generation
Density of MOS in Categories of Fill (8702-8801)
Grade E6

CATEGORY OF FILL / TARGET PROCESS	CRITICALLY UNDER	MODERATELY UNDER	BALANCED	MODERATELY OVER	CRITICALLY OVER	TOTAL
HISTORICAL	852	4,824	57,916	12,263	3,166	79,021
WINTERS	1,240	4,129	55,660	14,767	3,259	79,055
CURRENT	1,056	3,815	59,350	11,552	3,147	78,920
TUKEY & OUTLIER	1,2,07	3,173	59,768	11,628	3,152	78,928
OUTLIER (STR. - LINE)	1,197	3,035	59,813	11,584	3,308	78,936
AUTH (STAGE 6)	1,201	2,973	59,772	11,674	3,299	78,919
TUKEY	1,207	3,006	59,905	11,657	3,152	78,927
OUTLIER (MOVING AVG)	1,199	2,949	59,800	11,683	3,306	78,937
RAMP	1,218	3,094	59,215	12,277	3,136	78,939
AUTH (STAGE 2)	1,297	1,947	60,859	11,614	3,215	78,931

Table I-7. Comparison of Smoothing Techniques in Target Generation
Average Strength of MOS in Understrength and Overstrength (8702-8801)
Grade E5

TARGET PROCESS \ AVERAGE STRENGTH	UNDERSTRENGTH	OVERSTRENGTH
HISTORICAL	-4,979	2,945
WINTERS	-5,181	3,127
CURRENT	-4,721	2,715
TUKEY & OUTLIER	-4,702	2,709
OUTLIER (STR. - LINE)	-4,700	2,714
AUTH (STAGE 6)	-4,703	2,706
TUKEY	-4,664	2,698
OUTLIER (MOVING AVG)	-4,695	2,710
RAMP	-4,714	2,687
AUTH (STAGE 2)	-5,141	2,796

Table I-8. Comparison of Smoothing Techniques in Target Generation
Average Strength of MOS in Understrength and Overstrength (8702-8801)
Grade E6

TARGET PROCESS \ AVERAGE STRENGTH	UNDERSTRENGTH	OVERSTRENGTH
HISTORICAL	-1,591	2,487
WINTERS	-1,536	2,340
CURRENT	-1,554	2,351
TUKEY & OUTLIER	-1,743	2,675
OUTLIER (STR. - LINE)	-1,555	2,367
AUTH (STAGE 6)	-1,564	2,359
TUKEY	-1,535	2,338
OUTLIER (MOVING AVG)	-1,552	2,365
RAMP	-1,548	2,363
AUTH (STAGE 2)	-1,522	2,329

Table I-9. Smoothing Order Comparisons
Number of MOS in Categories of Fill (8702-8801)
Grade E5

TARGET PROCESS \ CATEGORY OF FILL	CRITICALLY UNDER	MODERATELY UNDER	BALANCED	MODERATELY OVER	CRITICALLY OVER	TOTAL
AUTH (STAGE 2), C	10	52	137	37	29	265
AUTH (STAGE 6), C	9	54	137	36	29	265
AUTH (STAGE 2), T	10	49	141	36	29	265
AUTH (STAGE 6), T	10	50	142	35	28	265
AUTH (STAGE 2) – OUTLIERS (SL)	10	49	141	36	29	265
AUTH (STAGE 6) – OUTLIERS (SL)	12	44	147	35	27	265
AUTH (STAGE 2) – OUTLIERS (MA)	10	49	142	36	29	265
AUTH (STAGE 6) – OUTLIERS (MA)	10	50	139	38	29	265
AUTH (STAGE 6)	10	49	141	36	29	265

C = CURRENT SMOOTHING TECHNIQUE
T = TUKEY STATISTICAL SMOOTHER

Table I-10. Smoothing Order Comparisons
Number of MOS in Categories of Fill (8702-8801)
Grade E6

TARGET PROCESS \ CATEGORY OF FILL	CRITICALLY UNDER	MODERATELY UNDER	BALANCED	MODERATELY OVER	CRITICALLY OVER	TOTAL
AUTH (STAGE 2), C	7	18	131	55	32	242
AUTH (STAGE 6), C	6	18	132	54	31	242
AUTH (STAGE 2), T	7	17	131	55	32	242
AUTH (STAGE 6), T	7	16	132	55	31	242
AUTH (STAGE 2) – OUTLIERS (SL)	7	17	131	54	33	265
AUTH (STAGE 6) – OUTLIERS (SL)	6	18	134	52	32	265
AUTH (STAGE 2) – OUTLIERS (MA)	7	16	131	55	33	242
AUTH (STAGE 6) – OUTLIERS (MA)	7	16	132	55	33	242
AUTH (STAGE 6)	8	11	139	53	32	242

C = CURRENT SMOOTHING TECHNIQUE
T = TUKEY STATISTICAL SMOOTHER

Table I-11. Smoothing Order Comparisons
Percentage of MOS in Categories of Fill (8702-8801)
Grade E5

CATEGORY OF FILL / TARGET PROCESS	CRITICALLY UNDER	MODERATELY UNDER	BALANCED	MODERATELY OVER	CRITICALLY OVER	TOTAL
AUTH (STAGE 2), C	4	20	52	14	11	100
AUTH (STAGE 6), C	4	20	52	14	11	100
AUTH (STAGE 2), T	4	19	53	14	11	100
AUTH (STAGE 6), T	4	19	54	13	11	100
AUTH (STAGE 2) - OUTLIERS (SL)	4	19	53	14	11	100
AUTH (STAGE 6) - OUTLIERS (SL)	4	17	55	13	10	100
AUTH (STAGE 2) - OUTLIERS (MA)	4	18	53	14	11	100
AUTH (STAGE 6) - OUTLIERS (MA)	4	19	52	14	11	100
AUTH (STAGE 6)	4	19	53	13	11	100

C = CURRENT SMOOTHING TECHNIQUE
T = TUKEY STATISTICAL SMOOTHER

Table I-12. Smoothing Order Comparisons
Percentage of MOS in Categories of Fill (8702-8801)
Grade E6

CATEGORY OF FILL / TARGET PROCESS	CRITICALLY UNDER	MODERATELY UNDER	BALANCED	MODERATELY OVER	CRITICALLY OVER	TOTAL
AUTH (STAGE 2), C	3	8	54	23	13	100
AUTH (STAGE 6), C	3	8	52	22	13	100
AUTH (STAGE 2), T	3	7	54	23	13	100
AUTH (STAGE 6), T	3	7	55	23	13	100
AUTH (STAGE 2) - OUTLIER (SL)	3	7	54	22	14	100
AUTH (STAGE 6) - OUTLIER (SL)	3	7	56	21	13	100
AUTH (STAGE 2) - OUTLIER (MA)	3	7	54	23	14	100
AUTH (STAGE 6) - OUTLIER (MA)	3	7	54	23	14	100
AUTH (STAGE 6)	3	7	54	22	14	100

C = CURRENT SMOOTHING TECHNIQUE
T = TUKEY STATISTICAL SMOOTHER

Table I-13. Smoothing Order Comparisons
Density of MOS in Categories of Fill (8702-8801)
Grade E5

TARGET PROCESS \ CATEGORY OF FILL	CRITICALLY UNDER	MODERATELY UNDER	BALANCED	MODERATELY OVER	CRITICALLY OVER	TOTAL
AUTH (STAGE 2), C	2,198	24,600	67,410	7,629	4,579	106,417
AUTH (STAGE 6), C	1,293	24,823	68,222	7,553	4,536	106,427
AUTH (STAGE 2), T	1,233	23,490	69,259	7,793	4,501	106,456
AUTH (STAGE 6), T	1,225	22,976	70,199	7,683	4,362	106,445
AUTH (STAGE 2) - OUTLIERS (SL)	1,226	24,024	68,468	8,121	4,597	106,436
AUTH (STAGE 6) - OUTLIERS (SL)	2,957	18,962	72,748	7,137	4,575	106,378
AUTH (STAGE 2) - OUTLIERS (MA)	1,226	23,790	68,831	8,000	4,591	106,437
AUTH (STAGE 6) - OUTLIERS (MA)	1,297	24,088	68,383	8,119	4,576	106,463
AUTH (STAGE 6)	1,227	24,154	68,457	8,004	4,583	106,425

C = CURRENT SMOOTHING TECHNIQUE
T = TUKEY STATISTICAL SMOOTHER

Table I-14. Smoothing Order Comparisons
Density of MOS in Categories of Fill (8702-8801)
Grade E6

TARGET PROCESS \ CATEGORY OF FILL	CRITICALLY UNDER	MODERATELY UNDER	BALANCED	MODERATELY OVER	CRITICALLY OVER	TOTAL
AUTH (STAGE 2), C	1,056	3,815	59,350	11,552	3,147	78,920
AUTH (STAGE 6), C	1,041	3,650	59,517	11,552	3,134	78,894
AUTH (STAGE 2), T	1,207	3,006	59,905	11,674	3,152	78,927
AUTH (STAGE 6), T	1,123	2,950	60,005	11,715	3,124	78,917
AUTH (STAGE 2) - OUTLIERS (SL)	1,197	3,035	59,813	11,584	3,308	78,936
AUTH (STAGE 6) - OUTLIERS (SL)	1,180	3,095	60,208	11,205	3,220	79,392
AUTH (STAGE 2) - OUTLIERS (MA)	1,199	2,949	59,800	11,683	3,306	78,937
AUTH (STAGE 6) - OUTLIERS (MA)	1,197	2,917	59,964	11,550	3,312	78,940
AUTH (STAGE 6)	1,201	2,973	59,772	11,674	3,299	78,919

C = CURRENT SMOOTHING TECHNIQUE
T = TUKEY STATISTICAL SMOOTHER

Table I-15. Smoothing Order Comparisons
Average Strength of MOS in Understrength and Overstrength (8702-8801)
Grade E5

TARGET PROCESS \ AVERAGE STRENGTH	UNDERSTRENGTH	OVERSTRENGTH
AUTH (STAGE 2), C	-4,721	2,945
AUTH (STAGE 6), C	-4,679	2,684
AUTH (STAGE 2), T	-4,664	2.698
AUTH (STAGE 6), T	-4,621	2,646
AUTH (STAGE 2) - OUTLIERS (SL)	-4,700	2,714
AUTH (STAGE 6) - OUTLIERS (SL)	-4,662	2,618
AUTH (STAGE 2) - OUTLIERS (MA)	-4,695	2,710
AUTH (STAGE 6) - OUTLIERS (MA)	-4,664	2,705
AUTH (STAGE 6)	-4,703	2,706

C = CURRENT SMOOTHING TECHNIQUE
T = TUKEY STATISTICAL SMOOTHER

Table I-16. Smoothing Order Comparisons
Average Strength of MOS in Understrength and Overstrength (8702-8801)
Grade E6

TARGET PROCESS \ AVERAGE STRENGTH	UNDERSTRENGTH	OVERSTRENGTH
AUTH (STAGE 2), C	-1,554	2,351
AUTH (STAGE 6), C	-1,555	2,326
AUTH (STAGE 2), T	-1,535	2.338
AUTH (STAGE 6), T	-1,520	2,314
AUTH (STAGE 2) - OUTLIERS (SL)	-1,555	2,367
AUTH (STAGE 6) - OUTLIERS (SL)	-1,556	2,340
AUTH (STAGE 2) - OUTLIERS (MA)	-1,552	2,365
AUTH (STAGE 6) - OUTLIERS (MA)	-1,561	2,376
AUTH (STAGE 6)	-1,564	2,359

C = CURRENT SMOOTHING TECHNIQUE
T = TUKEY STATISTICAL SMOOTHER

Table I-17. Protecting Selected Authorizations
Number of MOS in Categories of Fill (8702-8801)
Grade E5

CATEGORY OF FILL / TARGET PROCESS	CRITICALLY UNDER	MODERATELY UNDER	BALANCED	MODERATELY OVER	CRITICALLY OVER	TOTAL
TUKEY	10	49	141	36	29	265
T + SIMOS	12	45	145	35	28	265
A2	18	28	154	37	28	265
A2 + PS	18	27	152	39	29	265
A2 + PS + PD	17	27	153	39	29	265

TUKEY.

T + SIMOS: TUKEY + PROTECT AUTHORIZATIONS INFLATED FOR SPACE IMBALANCE AND OTHER UNDOCUMENTED REQUIREMENTS.

A2: AUTHORIZATIONS, STAGE 2.

A2 + PS: AUTHORIZATIONS, STAGE 2 + PROTECT AUTHORIZATIONS < 50.

A2 + PS + PD: AUTHORIZATIONS, STAGE 2 + PROTECT SMALL AUTHORIZATIONS + PROTECT INCREASING (DECREASING) AUTHORIZATIONS WHEN NUMBERS NEEDED ARE SCALED DOWNWARD (UPWARD).

Table I-18. Protecting Selected Authorizations
Number of MOS in Categories of Fill (8702-8801)
Grade E6

CATEGORY OF FILL / TARGET PROCESS	CRITICALLY UNDER	MODERATELY UNDER	BALANCED	MODERATELY OVER	CRITICALLY OVER	TOTAL
TUKEY	7	17	131	55	32	242
T + SIMOS	8	17	132	54	31	242
A2	8	11	139	53	31	242
A2 + PS	8	10	137	54	33	242
A2 + PS + PD	6	9	137	56	34	242

TUKEY.

T + SIMOS: TUKEY + PROTECT AUTHORIZATIONS INFLATED FOR SPACE IMBALANCE AND OTHER UNDOCUMENTED REQUIREMENTS.

A2: AUTHORIZATIONS, STAGE 2.

A2 + PS: AUTHORIZATIONS, STAGE 2 + PROTECT AUTHORIZATIONS < 50.

A2 + PS + PD: AUTHORIZATIONS, STAGE 2 + PROTECT SMALL AUTHORIZATIONS + PROTECT INCREASING (DECREASING) AUTHORIZATIONS WHEN NUMBERS NEEDED ARE SCALED DOWNWARD (UPWARD).

Table I-19. Protecting Selected Authorizations
Percentage of MOS in Categories of Fill (8702-8801)
Grade E5

TARGET PROCESS \ CATEGORY OF FILL	CRITICALLY UNDER	MODERATELY UNDER	BALANCED	MODERATELY OVER	CRITICALLY OVER	TOTAL
TUKEY	3.7	18.6	53.3	13.6	10.9	100
T + SIMOS	4.4	17.1	55.7	13.3	10.5	100
A2	6.9	10.7	58.1	13.9	10.5	100
A2 + PS	6.9	10.3	57.5	14.5	10.8	100
A2 + PS + PD	6.5	10.1	57.7	14.9	10.8	100

TUKEY.

T + SIMOS: TUKEY + PROTECT AUTHORIZATIONS INFLATED FOR SPACE IMBALANCE AND OTHER UNDOCUMENTED REQUIREMENTS.

A2: AUTHORIZATIONS, STAGE 2.

A2 + PS: AUTHORIZATIONS, STAGE 2 + PROTECT AUTHORIZATIONS < 50.

A2 + PS + PD: AUTHORIZATIONS, STAGE 2 + PROTECT SMALL AUTHORIZATIONS + PROTECT INCREASING (DECREASING) AUTHORIZATIONS WHEN NUMBERS NEEDED ARE SCALED DOWNWARD (UPWARD).

Table I-20. Protecting Selected Authorizations
Percentage of MOS in Categories of Fill (8702-8801)
Grade E6

TARGET PROCESS \ CATEGORY OF FILL	CRITICALLY UNDER	MODERATELY UNDER	BALANCED	MODERATELY OVER	CRITICALLY OVER	TOTAL
TUKEY	2.9	6.9	54.3	22.9	13.1	100
T + SIMOS	3.1	7.1	54.4	22.4	13.0	100
A2	3.1	4.5	57.2	22.0	13.2	100
A2 + PS	3.2	4.1	56.5	22.3	13.9	100
A2 + PS + PD	2.5	3.9	56.8	23.0	13.8	100

TUKEY.

T + SIMOS: TUKEY + PROTECT AUTHORIZATIONS INFLATED FOR SPACE IMBALANCE AND OTHER UNDOCUMENTED REQUIREMENTS.

A2: AUTHORIZATIONS, STAGE 2.

A2 + PS: AUTHORIZATIONS, STAGE 2 + PROTECT AUTHORIZATIONS < 50.

A2 + PS + PD: AUTHORIZATIONS, STAGE 2 + PROTECT SMALL AUTHORIZATIONS + PROTECT INCREASING (DECREASING) AUTHORIZATIONS WHEN NUMBERS NEEDED ARE SCALED DOWNWARD (UPWARD).

Table I-21. Protecting Selected Authorizations
Density of MOS in Categories of Fill (8702-8801)
Grade E5

TARGET PROCESS \ CATEGORY OF FILL	CRITICALLY UNDER	MODERATELY UNDER	BALANCED	MODERATELY OVER	CRITICALLY OVER	TOTAL
TUKEY	1,233	23,490	69,259	7,793	4,501	106,456
T + SIMOS	2,872	18,896	72,530	8,013	4,110	106,421
A2	4,338	10,856	79,449	6,857	4,577	106,077
A2 + PS	4,338	11,356	78,851	6,929	4,607	106,081
A2 + PS + PD	3,514	10,186	80,876	7,410	4,601	106,587

TUKEY.

T + SIMOS: TUKEY + PROTECT AUTHORIZATIONS INFLATED FOR SPACE IMBALANCE AND OTHER UNDOCUMENTED REQUIREMENTS.

A2: AUTHORIZATIONS, STAGE 2.

A2 + PS: AUTHORIZATIONS, STAGE 2 + PROTECT AUTHORIZATIONS < 50.

A2 + PS + PD: AUTHORIZATIONS, STAGE 2 + PROTECT SMALL AUTHORIZATIONS + PROTECT INCREASING (DECREASING) AUTHORIZATIONS WHEN NUMBERS NEEDED ARE SCALED DOWNWARD (UPWARD).

Table I-22. Protecting Selected Authorizations
Density of MOS in Categories of Fill (8702-8801)
Grade E6

TARGET PROCESS \ CATEGORY OF FILL	CRITICALLY UNDER	MODERATELY UNDER	BALANCED	MODERATELY OVER	CRITICALLY OVER	TOTAL
TUKEY	1,207	3,006	59,905	11,657	3,152	78,927
T + SIMOS	1,115	2,834	60,288	11,609	3,143	78,989
A2	1,297	1,947	60,859	11,614	3,215	78,931
A2 + PS	1,300	1,934	60,764	11,663	3,264	78,925
A2 + PS + PD	735	1,730	61,137	12,550	3,292	79,444

TUKEY.

T + SIMOS: TUKEY + PROTECT AUTHORIZATIONS INFLATED FOR SPACE IMBALANCE AND OTHER UNDOCUMENTED REQUIREMENTS.

A2: AUTHORIZATIONS, STAGE 2.

A2 + PS: AUTHORIZATIONS, STAGE 2 + PROTECT AUTHORIZATIONS < 50.

A2 + PS + PD: AUTHORIZATIONS, STAGE 2 + PROTECT SMALL AUTHORIZATIONS + PROTECT INCREASING (DECREASING) AUTHORIZATIONS WHEN NUMBERS NEEDED ARE SCALED DOWNWARD (UPWARD).

Table I-23. Protecting Selected Authorizations
Average Strength of MOS in Understrength and Overstrength (8702-8801)
Grade E5

TARGET PROCESS \ AVERAGE STRENGTH	UNDERSTRENGTH	OVERSTRENGTH
TUKEY	-4,664	2,698
T + SIMOS	-4,642	2,640
A2	-5,141	2,796
A2 + PS	-5,148	2,807
A2 + PS + PD	-4,711	2,876

TUKEY.

T + SIMOS: TUKEY + PROTECT AUTHORIZATIONS INFLATED FOR SPACE IMBALANCE AND OTHER UNDOCUMENTED REQUIREMENTS.

A2: AUTHORIZATIONS, STAGE 2.

A2 + PS: AUTHORIZATIONS, STAGE 2 + PROTECT AUTHORIZATIONS < 50.

A2 + PS + PD: AUTHORIZATIONS, STAGE 2 + PROTECT SMALL AUTHORIZATIONS + PROTECT INCREASING (DECREASING) AUTHORIZATIONS WHEN NUMBERS NEEDED ARE SCALED DOWNWARD (UPWARD).

Table I-24. Protecting Selected Authorizations
Average Strength of MOS in Understrength and Overstrength (8702-8801)
Grade E6

TARGET PROCESS \ AVERAGE STRENGTH	UNDERSTRENGTH	OVERSTRENGTH
TUKEY	-1,535	2,338
T + SIMOS	-1,473	2,339
A2	-1,522	2,329
A2 + PS	-1,532	2,334
A2 + PS + PD	-1,170	2,490

TUKEY.

T + SIMOS: TUKEY + PROTECT AUTHORIZATIONS INFLATED FOR SPACE IMBALANCE AND OTHER UNDOCUMENTED REQUIREMENTS.

A2: AUTHORIZATIONS, STAGE 2.

A2 + PS: AUTHORIZATIONS, STAGE 2 + PROTECT AUTHORIZATIONS < 50.

A2 + PS + PD: AUTHORIZATIONS, STAGE 2 + PROTECT SMALL AUTHORIZATIONS + PROTECT INCREASING (DECREASING) AUTHORIZATIONS WHEN NUMBERS NEEDED ARE SCALED DOWNWARD (UPWARD).

Table I-25. Effects of Selective Smoothing Processes
Number of MOS in Categories of Fill (8702-8801)
Grade E5

TARGET PROCESS \ CATEGORY OF FILL	CRITICALLY UNDER	MODERATELY UNDER	BALANCED	MODERATELY OVER	CRITICALLY OVER	TOTAL
AUTH (STAGE 2)	18	28	154	37	28	265
AUTH (STAGE 2)* - STEPS, OUTLIERS (T)	13	24	154	45	29	265
AUTH (STAGE 2)* - STEPS, OUTLIERS (R)	14	25	152	45	29	265

*ALSO, PROTECT AUTHORIZATIONS ≤ 50
T = TUKEY STATISTICAL SMOOTHER
R = CONSTRUCTION RAMPS

Table I-26. Effects of Selective Smoothing Processes
Number of MOS in Categories of Fill (8702-8801)
Grade E6

TARGET PROCESS \ CATEGORY OF FILL	CRITICALLY UNDER	MODERATELY UNDER	BALANCED	MODERATELY OVER	CRITICALLY OVER	TOTAL
AUTH (STAGE 2)	8	11	139	53	31	242
AUTH (STAGE 2)* - STEPS, OUTLIERS (T)	5	6	140	56	35	242
AUTH (STAGE 2)* - STEPS, OUTLIERS (R)	5	6	140	57	34	242

*ALSO, PROTECT AUTHORIZATONS ≤ 50
T = TUKEY STATISTICAL SMOOTHER
R = CONSTRUCTION OF RAMPS

Table I-27. Effects of Selective Smoothing Processes
Percentage of MOS in Categories of Fill (8702-8801)
Grade E5

TARGET PROCESS \ CATEGORY OF FILL	CRITICALLY UNDER	MODERATELY UNDER	BALANCED	MODERATELY OVER	CRITICALLY OVER	TOTAL
AUTH (STAGE 2)	7	11	58	14	11	100
AUTH (STAGE 2)* - STEPS, OUTLIERS (T)	5	10	58	17	11	100
AUTH (STAGE 2)* - STEPS, OUTLIERS (R)	5	9	58	17	11	100

*ALSO, PROTECT AUTHORIZATIONS ≤ 50
T = TUKEY STATISTICAL SMOOTHER
R = CONSTRUCTION OF RAMPS

Table I-28. Effects of Selective Smoothing Processes
Percentage of MOS in Categories of Fill (8702-8801)
Grade E6

TARGET PROCESS \ CATEGORY OF FILL	CRITICALLY UNDER	MODERATELY UNDER	BALANCED	MODERATELY OVER	CRITICALLY OVER	TOTAL
AUTH (STAGE 2)	3	5	57	22	13	100
AUTH (STAGE 2)* - STEPS, OUTLIERS (T)	2	3	58	23	14	100
AUTH (STAGE 2)* - STEPS, OUTLIERS (R)	2	3	58	23	14	100

*ALSO, PROTECT AUTHORIZATIONS ≤ 50
T = TUKEY STATISTICAL SMOOTHER
R = CONSTRUCTION OF RAMPS

Table I-29. Effects of Selective Smoothing Processes
Density of MOS in Categories of Fill (8702-8801)
Grade E5

TARGET PROCESS \ CATEGORY OF FILL	CRITICALLY UNDER	MODERATELY UNDER	BALANCED	MODERATELY OVER	CRITICALLY OVER	TOTAL
AUTH (STAGE 2)	4,338	10,856	79,449	6,857	4,577	106,077
AUTH (STAGE 2)* – STEPS, OUTLIERS (T)	2,738	10,822	80,192	9,243	4,479	107,474
AUTH (STAGE 2)* – STEPS, OUTLIERS (R)	2,751	11,416	79,595	9,536	4,151	107,449

*ALSO, PROTECT AUTHORIZATIONS ≤ 50
T = TUKEY STATISTICAL SMOOTHER
R = CONSTRUCTION OF RAMPS

Table I-30. Effects of Selective Smoothing Processes
Density of MOS in Categories of Fill (8702-8801)
Grade E6

TARGET PROCESS \ CATEGORY OF FILL	CRITICALLY UNDER	MODERATELY UNDER	BALANCED	MODERATELY OVER	CRITICALLY OVER	TOTAL
AUTH (STAGE 2)	1,297	1,947	60,859	11,205	3,220	70,392
AUTH (STAGE 2)* – STEPS, OUTLIERS (T)	685	1,027	62,062	12,047	3,841	79,662
AUTH (STAGE 2)* – STEPS, OUTLIERS (R)	678	952	62,108	12,191	3,710	79,639

*ALSO, PROTECT AUTHORIZATIONS ≤ 50
T = TUKEY STATISTICAL SMOOTHER
R = CONSTRUCTION OF RAMPS

Table I-31. Effects of Selective Smoothing Processes
Average Strength of MOS in Understrength and Overstrength (8702-8801)
Grade E5

TARGET PROCESS \ AVERAGE NUMBER	UNDERSTRENGTH	OVERSTRENGTH
AUTH (STAGE 2)	-5,141	2,796
AUTH (STAGE 2)* - STEPS, OUTLIERS (T)	-4,127	3,179
AUTH (STAGE 2)* - STEPS, OUTLIERS (R)	-4,140	3,166

*ALSO, PROTECT AUTHORIZATIONS ≤ 50
T = TUKEY STATISTICAL SMOOTHER
R = CONSTRUCTION OF RAMPS

Table I-32. Effects of Selective Smoothing Processes
Average Strength of MOS in Understrength and Overstrength (8702-8801)
Grade E6

TARGET PROCESS \ AVERAGE NUMBER	UNDERSTRENGTH	OVERSTRENGTH
AUTH (STAGE 2)	-1,522	2,329
AUTH (STAGE 2)* - STEPS, OUTLIERS (T)	-1,034	2,571
AUTH (STAGE 2)* - STEPS, OUTLIERS (R)	-1,042	2,557

*ALSO, PROTECT AUTHORIZATIONS ≤ 50
T = TUKEY STATISTICAL SMOOTHER
R = CONSTRUCTION OF RAMPS

Table I-33. Comparison of Target Generation Processes
Number of MOS in Categories of Fill (8702-88-1)
Grade E5

TARGET PROCESS \ CATEGORY OF FILL	CRITICALLY UNDER	MODERATELY UNDER	BALANCED	MODERATELY OVER	CRITICALLY OVER	TOTAL
HISTORICAL	10	60	128	37	30	265
CURRENT	10	52	137	37	29	265
AUTH STAGE 6	10	49	141	36	29	265
TUKEY	10	49	141	36	29	265
RAMP	11	48	142	37	28	265
AUTH (STAGE 6) OUTLIER	12	44	147	35	27	265
AUTH (STAGE 2)	18	28	154	37	28	265
AUTH (STAGE 2) STEPS, OUTLIERS	13	24	154	45	29	265

*ALSO, PROTECT SMALL MOS ($\leq$ 50)

Table I-34. Comparison of Target Generation Processes
Number of MOS in Categories of Fill (8702-88-1)
Grade E6

TARGET PROCESS \ CATEGORY OF FILL	CRITICALLY UNDER	MODERATELY UNDER	BALANCED	MODERATELY OVER	CRITICALLY OVER	TOTAL
HISTORICAL	8	21	122	59	33	242
RAMP	7	17	130	57	32	242
CURRENT	7	18	131	55	32	242
AUTH STAGE 6	7	17	131	54	33	242
TUKEY	7	17	131	55	32	242
AUTH (STAGE 6) OUTLIERS	6	18	134	52	32	242
AUTH (STAGE 2)	8	11	139	53	32	242
AUTH (STAGE 2) STEPS, OUTLIERS	5	6	140	56	35	242

*ALSO, PROTECT SMALL MOS ($\leq$ 50)

Table I-35. Comparison of Target Generation Processes
Percentage of MOS in Categories of Fill (8702-88-1)
Grade E5

TARGET PROCESS \ CATEGORY OF FILL	CRITICALLY UNDER	MODERATELY UNDER	BALANCED	MODERATELY OVER	CRITICALLY OVER	TOTAL
HISTORICAL	4	23	48	14	11	100
CURRENT	4	20	52	14	11	100
AUTH (STAGE 6)	4	19	53	13	11	100
TUKEY	4	19	53	14	11	100
RAMP	4	18	54	14	11	100
AUTH (STAGE 6) - OUTLIERS	4	17	55	13	10	100
AUTH (STAGE 2)	7	11	58	14	11	100
AUTH (STAGE 2)* - STEPS, OUTLIERS	6	9	58	15	11	100

*ALSO, PROTECT SMALL MOS (≤ 50)

Table I-36. Comparison of Target Generation Processes
Percentage of MOS in Categories of Fill (8702-88-1)
Grade E6

TARGET PROCESS \ CATEGORY OF FILL	CRITICALLY UNDER	MODERATELY UNDER	BALANCED	MODERATELY OVER	CRITICALLY OVER	TOTAL
HISTORICAL	3	9	51	24	14	100
CURRENT	3	8	54	23	13	100
RAMP	3	7	54	23	13	100
AUTH (STAGE 6)	3	7	54	22	14	100
TUKEY	3	7	54	23	13	100
AUTH (STAGE 6) - OUTLIERS	3	7	56	21	13	100
AUTH (STAGF 2)	3	5	57	22	13	100
AUTH (STAGE 2)* - STEPS, OUTLIERS	3	4	57	22	14	100

*ALSO, PROTECT SMALL MOS (≤ 50)

Table I-37. Comparison of Target Generation Processes
Density of MOS in Categories of Fill (8702-8801)
Grade E5

TARGET PROCESS \ CATEGORY OF FILL	CRITICALLY UNDER	MODERATELY UNDER	BALANCED	MODERATELY OVER	CRITICALLY OVER	TOTAL
HISTORICAL	1,412	27,239	63,162	9,923	4,652	106,388
CURRENT	2,198	24,600	67,410	7,629	4,579	106,417
AUTH (STAGE 6)	1,227	24,154	68,457	8,004	4,583	106,425
RAMP	2,865	22,250	69,036	8,160	4,083	106,395
TUKEY	1,233	23,490	69,259	7,793	4,501	106,456
AUTH (STAGE 6) – OUTLIERS	2,957	18,962	72,748	7,137	4,575	106,378
AUTH (STAGE 2)	4,338	10,856	79,449	6,857	4,577	106,077
AUTH (STAGE 2)* – STEPS, OUTLIERS	2,738	10,821	80,192	9,243	4,478	107,472

*ALSO, PROTECT SMALL MOS (≤ 50)

Table I-38. Comparison of Target Generation Processes
Density of MOS in Categories of Fill (8702-8801)
Grade E6

TARGET PROCESS \ CATEGORY OF FILL	CRITICALLY UNDER	MODERATELY UNDER	BALANCED	MODERATELY OVER	CRITICALLY OVER	TOTAL
HISTORICAL	852	4,824	57,916	12,263	3,166	79,021
RAMP	1,218	3,094	59,215	12,277	3,136	78,939
CURRENT	1,056	3,815	59,350	11,552	3,147	78,920
AUTH (STAGE 6)	1,201	2,973	59,772	11,674	3,299	78,919
AUTH (STAGE 6) – OUTLIERS	1,180	3,095	60,208	11,205	3,220	79,392
TUKEY	1,207	3,006	59,905	11,657	3,152	78,927
AUTH (STAGE 2)	1,297	1,947	60,859	11,614	3,215	78,931
AUTH (STAGE 2)* – STEPS, OUTLIERS	684	1,026	62,062	12,047	3,840	79,659

*ALSO, PROTECT SMALL MOS (≤ 50)

Table I-39. Comparison of Target Generation Processes
Average Strength of MOS in Understrength and Overstrength (8702-8801)
Grade E5

AVERAGE STRENGTH / TARGET PROCESS	UNDERSTRENGTH	OVERSTRENGTH
AUTH (STAGE 2)* - STEPS, OUTLIERS	-4,127	3,179
HISTORICAL	-4,979	2,945
AUTH (STAGE 2)	-5,141	2,796
CURRENT	-4,721	2,715
AUTH (STAGE 6)	-4,703	2,706
TUKEY	-4,664	2,698
RAMP	-4,717	2,687
AUTH (STAGE 6) - OUTLIERS	-4,662	2,618

*ALSO, PROTECT SMALL MOS (≤ 50)

Table I-40. Comparison of Target Generation Processes
Average Strength of MOS in Understrength and Overstrength (8702-8801)
Grade E6

AVERAGE STRENGTH / TARGET PROCESS	UNDERSTRENGTH	OVERSTRENGTH
AUTH (STAGE 2)* - STEPS, OUTLIERS	-1,033	2,570
HISTORICAL	-1,591	2,487
RAMP	-1,548	2,363
AUTH (STAGE 6)	-1,564	2,359
AUTH (STAGE 6) - OUTLIERS	-1,556	2,340
CURRENT	-1,554	2,351
TUKEY	-1,535	2,338
AUTH (STAGE 2)	-1,522	2,329

*ALSO, PROTECT SMALL MOS (≤ 50)

APPENDIX J

SPONSOR'S COMMENTS

DEPARTMENT OF THE ARMY
OFFICE OF THE DEPUTY CHIEF OF STAFF FOR PERSONNEL
WASHINGTON, DC 20310-0300

REPLY TO
ATTENTION OF
DAPE-MBF 3 October 1988

MEMORANDUM FOR DIRECTOR, CONCEPTS ANALYSIS AGENCY,
ATTN: CSCA-FSP, 8120 WOODMONT AVENUE,
BETHESDA, MARYLAND 20814-2797

SUBJECT: E5/E6 Target Generation (TARGEN) Draft Study Report

1. Reference your memorandum dated 30 August 1988, subject as above.

2. The draft study report has been reviewed and critique sheets are provided as Enclosure 1. The report is well written and addresses all key issues within the scope of the project. Based on the recomendations made by the study director at her final briefing to the Study Advisory Group (SAG) and presented in the draft study report, the Army has undertaken a three phase process to incorporate those recommendations.

3. Recommend you change the office symbol in your proposed distribution list from DAPE-ZBR to DAPE-ZB and add distribution to Deputy Chief of Staff for Personnel (DAPE-MB and DAPE-MP).

FOR THE DIRECTOR:

1 Encl

JOHN C. CARTLAND, JR.
Colonel, GS
Chief, Force Alignment,
Plans and Analysis Division

STUDY CRITIQUE

(This document may be modified to add more space for responses to questions.)

1. Are there any editorial comments? NO If so, please list on a separate page and attach to the critique sheet.

2. Identify any key issues planned for analysis that are not adequately addressed in the report. Indicate the scope of the additional analysis needed. All key issues adequately addressed within the scope of the project.

3. How can the methodology used to conduct the study be improved?

no recommendation

4. What additional information should be included in the study report to more clearly demonstrate the bases for the study findings? Study report clearly explains the bases for the study findings - no additional information necessary

5. How can the study findings be better presented to support the needs of both action officers and decisionmakers? no recommendations

6. How can the written material in the report be improved in terms of clarity of presentation, completeness, and style? no recommendations

STUDY CRITIQUE (continued)

7. How can figures and tables in the report be made more clear and helpful? Tables and figures are clear and support the text portion of the report.

8. In what way does the report satisfy the expectations that were present when the work was directed? Report fully satisfies expectations - it does, however, identify other areas for study/analysis

In what ways does the report fail to satisfy the expectations?

—

9. How will the findings in this report be helpful to the organization which directed that the work be done? Report is a good tool for gaining an understanding of the budget generation process of the ES/EC promotion system - also a good check of the current process. Insights gained from intermediate analysis were also beneficial

If they will not be helpful, please explain why not.

10. Judged overall, how do you rate the study? (circle one)

Poor Fair Average Good Excellent

APPENDIX K

DISTRIBUTION

Addressee	No of copies
Deputy Chief of Staff for Operations and Plans Headquarters, Department of the Army ATTN: DAMO-ZA Washington, DC 20310	1
Deputy Chief of Staff for Operations and Plans Headquarters, Department of the Army ATTN: DAMO-ZD Washington, DC 20310	1
Deputy Chief of Staff for Operations and Plans Headquarters, Department of the Army ATTN: DAMO-ZDF Washington, DC 20310	1
Deputy Chief of Staff for Personnel Headquarters, Department of the Army ATTN: DAPE-ZA Washington, DC 20310	1
Deputy Chief of Staff for Personnel Headquarters, Department of the Army ATTN: DAPE-MB Washington, DC 20310	1
Deputy Chief of Staff for Personnel Headquarters, Department of the Army ATTN: DAPE-ZB Washington, DC 20310	1
Deputy Chief of Staff for Logistics Headquarters, Department of the Army ATTN: DAPE-MP Washington, DC 20310	1

Addressee	No of copies
Deputy Under Secretary of the Army (Operations Research) Washington, DC 20310	1
Chief of Staff, Army ATTN: DACS-DMO Washington, DC 20310	1
Assistant Secretary of the Army (Manpower & Reserve Affairs) Washington, DC 20310	1
Assistant Secretary of the Army (Research, Development, and Acquisition) Washington, DC 20310	1
Director US Army TRADOC Analysis Center White Sands Missile Range, NM 88002	1
Commander Combined Arms Combat Development Activity Fort Leavenworth, KS 66027	1
Commander Army Research Institute 5001 Eisenhower Avenue Alexandria, VA 22333	1
Commander US Army Military Personnel Center 200 Stovall Street Alexandria, VA 22332	2

Addressee	No of copies
Defense Technical Information Center ATTN: DTIC-DDA Cameron Station Alexandria, VA 22314-6145	2
Commander US Army Research, Development, and Acquisition Information Systems Agency Radford, VA 24141	1
The Pentagon Library (Army Studies Section) ATTN: ANRAL-RS The Pentagon Washington, DC 20310	1
Commander US Army Forces Command ATTN: AFOP-OM Fort McPherson, GA 30330	1
Director Program Analysis and Evaluation Office of the Secretary of Defense Room 2E330 The Pentagon Washington, DC 20310	1
Organization of the Joint Chiefs of Staff ATTN: J-8 Room 1D936, The Pentagon Washington, DC 20310	1
Commandant US Army War College Carlisle Barracks, PA 17013	1

Addressee	No of copies
Commandant US Army War College ATTN: Library Carlisle Barracks, PA 17013	1
President National Defense University ATTN: NDU-LD-CDC Washington, DC 20319-6000	1
Commandant US Army Command and General Staff College Fort Leavenworth, KS 66027	1
Superintendent United States Military Academy ATTN: Mathematics Department West Point, NY 10996	1
Superintendent United States Military Academy ATTN: Engineering Department West Point, NY 10996	1
Superintendent Naval Postgraduate School Monterey, CA 93940	1
Naval Postgraduate School ATTN: Department of Operations Research Code 55PY (Professor Parry) Monterey, CA 93940	1
Commander in Chief United States Readiness Command ATTN: RCDA MacDill Air Force Base, FL 33608	1

Addressee	No of copies
Commander US Army Western Command ATTN: APOP-SPM Fort Shafter, HI 96858-5100	1
Commander US Army Health Services Command Fort Sam Houston, TX 78234	1

Internal Distribution:

Unclassified Library	2

GLOSSARY

1. ABBREVIATIONS, ACRONYMS, AND SHORT TERMS

DMO	direct military overstrength
EEA	essential element(s) of analysis
ELIM	Enlisted Loss Inventory Model
EPM	E5/E6 Enlisted Promotion Model (study)
FAP I	Force Alignment Plan I (The Army Enlisted Personnel Management Plan (FY 1987-91)), FY 86
FY	fiscal year
GRC	General Research Corporation
HQDA	Headquarters, Department of the Army
MALOF	minimum authorized level of fill
MOS	military occupational specialty(ies)
MOSLS	MOS Level System
ODCSPER	Office of the Deputy Chief of Staff for Personnel
PMAD	primary authorizations documents (restructured every 6 months)
PAM	Personnel Authorizations Module of the FORECAST/MOSLS System
SIMOS	space imbalanced MOS
TAADS	The Army Authorization Documents System
TAPA	US Total Army Personnel Agency
THS	TTHS account, transients not counted
TTHS	trainees, transients, holdees, and students (account)
UAD	monthly update of the PMAD

2. DEFINITIONS

authorized strength

that portion of the required manpower which can be supported by allocated manpower and which is reflected in the authorized columns of current or projected authorization documents. Because of budgetary constraints, authorized manpower may be less than required manpower; however, depending on missions and priorities, the authorized manpower (military and/or civilian) may equal, but never exceed, the required manpower in modification tables of organization and equipment/tables of distribution and allowances

balance of strength

the degree to which target (authorized) strength is maintained in each MOS by grade

categories of fill

ranges of fill used to measure balance of strength (The Army Enlisted Personnel Management Plan (FY 1987-91)), FY 86 Edition:

critically imbalanced, underfill,	fill $\le$ .80
moderately imbalanced, underfill	.80 < fill $\le$ .95
balanced	.95 < fill $\le$ 1.05
moderately imbalanced, overfill,	1.05 < fill $\le$ 1.20
critically imbalanced, overfill,	1.20 < fill

coefficient of variation (CV)

CV = σ/μ * 100, where σ = standard deviation; μ = mean

cut scores (or cutoff scores)

the promotion point cutoff scores which are announced Armywide by the Department of the Army to promote eligible soldiers into grades E5 and E6 to meet the needs of the Army

density

actual strength in any category of fill by MOS and grade

fill (operating fill)

the ratio of operating strength to target (authorized) strength or the ratio of inventory strength to target strength modeled to incorporate the THS account

FORECAST/MOSLS

FORECAST is an umbrella system composed of primary systems to model the strength of officer and enlisted personnel of the Active and Reserve Components and civilian personnel. Shared modules interface the personnel community with managers in other functional areas (e.g., budget and force structure). FORECAST models force projections for both peacetime and mobilization. MOSLS, which is a part of the FORECAST System, projects the personnel management actions--e.g., training, promotion, and reclassification--that will result in the closest possible match between inventory and target for each MOS-grade pair

inventory strength
operating strength plus the number of soldiers categorized as trainees, holdees, and students (the THS account)

operating strength
applies to present and absent strength of an organization classified under the item "personnel status" of the morning report heading as "permanent party." Does not include "intransit" strength. Separate identification of operating strength will provide strength data necessary for unit readiness reporting.

overfill
fill greater than 1.0

overstrength
the number of soldiers for which operating/inventory strength is greater than target (authorized) strength by MOS and grade

promotion ceiling
the maximum number of promotions for a particular month which is dictated by ODCSPER

promotion determination
the number needed for promotion for a particular month constrained to the promotion ceiling for that month

strength differential
total operating strength minus total target strength over all MOS by grade

target strength
authorized strength which is aggregated, normalized, smoothed, and projected to better meet manpower requirements over time (modeled by General Research Corporation)

trained strength
same as inventory strength

underfill
fill less than 1.0

understrength
the number of soldiers for which operating/inventory strength is less than target (authorized) strength by MOS and grade